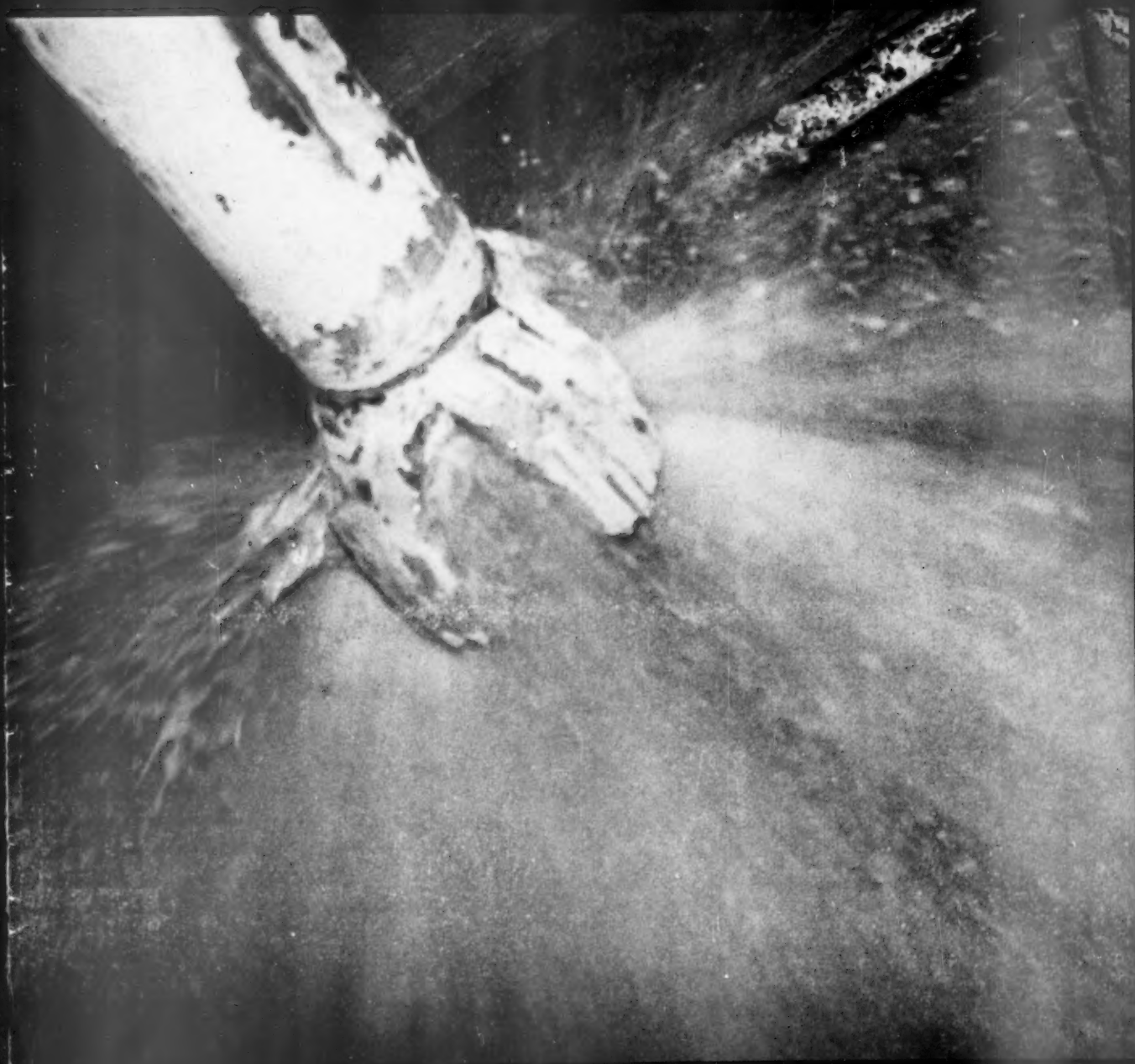
JOURNAL OF

Petroleum Technology



OCTOBER, 1953

THE OLD DUTCHMEN SAID:

'Koop geen knollen voor citroenen'

(DON'T BUY TURNIPS FOR LEMONS)

YOU CAN DEPEND ON SCHLUMBERGER

WHY OPERATORS PREFER
SCHLUMBERGER

Schlumberger Well Surveying Corp. • Houston, Texas

Jo Spier

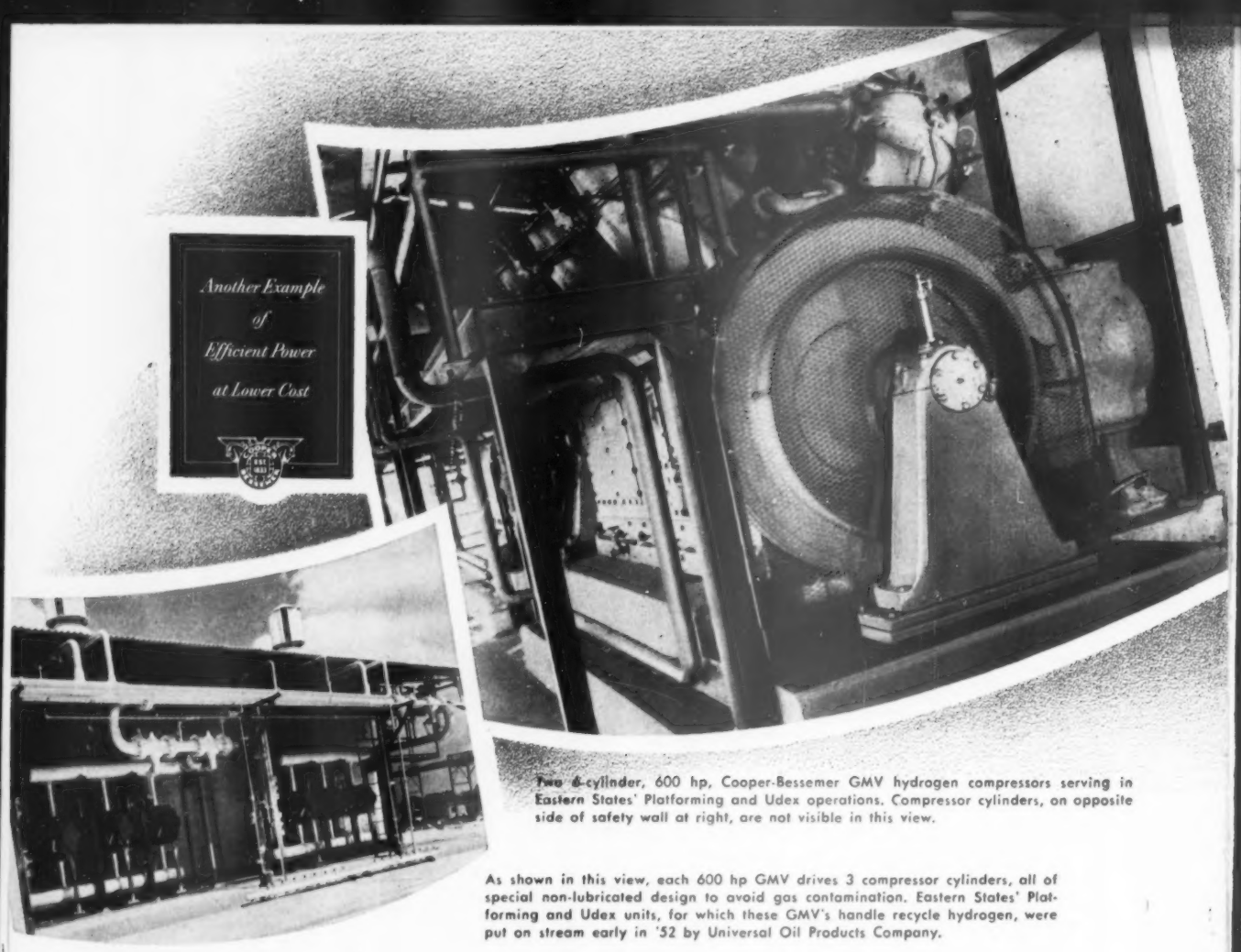
"What else need be said?"

CEMENTING

HALLIBURTON OIL WELL CEMENTING COMPANY
DUNCAN, OKLAHOMA

PERPETUAL PROGRESS IN PRODUCTION IMPROVEMENT TECHNIQUES

Another Example of Efficient Power at Lower Cost



Two 6-cylinder, 600 hp, Cooper-Bessemer GMV hydrogen compressors serving in Eastern States' Platforming and Udex operations. Compressor cylinders, on opposite side of safety wall at right, are not visible in this view.

As shown in this view, each 600 hp GMV drives 3 compressor cylinders, all of special non-lubricated design to avoid gas contamination. Eastern States' Platforming and Udex units, for which these GMV's handle recycle hydrogen, were put on stream early in '52 by Universal Oil Products Company.

THEY LICKED A TOUGH PROBLEM

in Eastern States' Platforming Unit with Cooper-Bessemer GMV's

THE two GMV's shown here operate as recycle hydrogen compressors for the remarkable new Platforming and Udex units in the Houston refinery of Eastern States Petroleum Company, Inc.

In this processing it was particularly important to avoid contamination of the recycle gas. To solve this problem, Cooper-Bessemer successfully developed *non-lubricated compressor cylinders* with light carbon pistons and segmented carbon rings. Moreover, cylinder bores were honed to a mirror finish of 4 to 6 micro inches. Now, after thousands of hours of operation, checks show no excessive wear anywhere.

If you have a similar problem, or compressor requirements of virtually *any* type, you'll find Cooper-Bessemer ready to cooperate . . . as usual . . . all the way.

The **Cooper-Bessemer** *Corporation*

MOUNT VERNON, OHIO — GROVE CITY, PENNA.

New York City Washington, D. C. Bradford, Pa. San Francisco
Houston, Dallas, Greggton, Pampa and Odessa, Texas Seattle, Wash.
Shreveport, La. St. Louis, Mo. Los Angeles, Calif. Gloucester, Mass.
Tulsa, Okla. New Orleans, La.

JOURNAL OF
Petroleum Technology

EDITORIAL BOARD
CLAUDE R. HOCOTT
PAUL R. TURNBULL
THOMAS C. FRICK

EDITORIAL DIRECTOR
JOE B. ALFORD

EDITOR
JESS E. ADKINS

MANAGING EDITOR
VIRGINIA BEILHARZ

EDITORIAL ASSISTANTS
BEKY YODER
HELEN TAUBMAN
MURIEL RALPH

ADVERTISING MANAGER
RICHARD C. WIPPERMAN

EASTERN ADVERTISING SALES
LEWIS V. HOHL
205 E. 42nd St., New York, N. Y.

JOURNAL OF PETROLEUM TECHNOLOGY is published monthly by the Petroleum Branch, American Institute of Mining and Metallurgical Engineers, Inc., at 800 Fidelity Union Bldg., Dallas 1, Tex. Entered as second class matter at the Post Office at Dallas, Tex. Domestic Subscription: North, South and Central America, $8; foreign, $10; to AIME members, $6 (or $4 if in combination with subscription to either Journal of Metals or Mining Engineering). Single copies, 75 cents; special issues, $1.50. Registered cable address, AIME. Printed in USA. Copyright 1953 by American Institute of Mining and Metallurgical Engineers, Inc.

Official Publication of the

PETROLEUM BRANCH
American Institute of Mining and Metallurgical Engineers, Inc.

800 Fidelity Union Bldg.
Dallas, Texas

Statements and opinions contained in the JOURNAL OF PETROLEUM TECHNOLOGY are, unless otherwise indicated, attributable only to the author, and do not necessarily reflect the views of the AIME, its officers, committees or other agencies.

The AIME also publishes:
Mining Engineering
Journal of Metals

OFFICERS of the PETROLEUM BRANCH

Chairman
Claude R. Hocott
Humble Oil and Refining Co.
Houston, Texas

Vice-Chairmen

John P. Hammond
Amerada Petroleum Corp.
Tulsa, Okla.

Basil P. Kantzer
Union Oil Co. of California
Los Angeles, Calif.

EXECUTIVE COMMITTEE

Thomas A. Atkinson
Socony-Vacuum Oil Co.
Casper, Wyo.

Roland Gouldy
Hull-Silk Repressuring Assoc.
Wichita Falls, Texas

John S. Bell
Humble Oil and Refining Co.
Los Angeles, Calif.

E. N. Van Duzee
Shell Oil Co.
New York, N. Y.

Thomas C. Frick
Atlantic Refining Co.
Corpus Christi, Texas

G. L. Yates
Amstutz & Yates
Wichita, Kansas

Paul R. Turnbull
Vaughan, Zoch & Turnbull
Corpus Christi, Texas

Paul R. Schultz
Stanolind Oil & Gas Co.
Tulsa, Okla.
Representing M.E.D.

Charles R. Dodson
Stanley, Stolz & Dodson
Los Angeles, Calif.
Representing M.I.E.D.

Treasurer
W. E. Stiles
Buffalo Oil Co.
Dallas, Texas

Executive Secretary
Joe B. Alford
AIME
Dallas, Texas

Counsel
Robert E. Hardwicke
Hardwicke, Haddaway & Pope
Fort Worth, Texas

COMMITTEE CHAIRMEN and VICE-CHAIRMEN

Admissions
J. H. Sullivan
Atlantic Refining Co.
Dallas, Texas

Advertising
Bruce Barkis
B & W, Inc.
Houston, Texas

Economics
Douglas S. Ball
Petroleum Consultant
Washington, D. C.

Education
John C. Calhoun, Jr.
Pennsylvania State College
State College, Pa.

Membership
M. B. Penn
Mid-Continent Petroleum Corp.
Tulsa, Okla.

Nominating
Paul R. Turnbull
Vaughan, Zoch and Turnbull
Corpus Christi, Texas

Publications
R. A. Morse
Stanolind Oil and Gas Co.
Tulsa, Okla.

Student Activities
W. S. Morris
East Texas Salt Water Disposal Co.
Kilgore, Texas

Production Review
R. B. Gilmore, Chairman
DeGolyer and MacNaughton
Dallas, Texas

Milton Williams, Domestic
Humble Oil and Refining Co.
Houston, Texas

A. H. Chapman, Foreign
Arabian American Oil Co.
Washington, D. C.

Technology
William H. Justice, Chairman
La Gloria Corp.
Corpus Christi, Texas

Preston E. Chaney, Drilling
Sun Oil Co.
Beaumont, Texas

Don C. Harlan, Production
The Texas Co.
Houston, Tex.

W. F. Speaker, Gas
Magnolia Petroleum Co.
Dallas, Texas

Clarence C. Liedholm, California
Signal Oil and Gas Co.
Los Angeles, Calif.

OFFICERS OF THE AIME

President, Andrew Fletcher; Vice-Presidents, J. L. Gillson, O. B. J. Fraser, J. B. Morrow, L. E. Elkins A. B. Kinzel and T. B. Counselman; President-Elect, L. F. Reinartz; Past-President, Michael L. Haider; Treasurer and Controller, G. I. Brigden; Secretary, E. H. Robie.

exploration

26.5 per cent of the members of the Petroleum Branch of the A.I.M.E. influence the exploration services and equipment used by their firms. Surprising? Not at all. The petroleum engineer's work begins with the lease block and ends with the last barrel of oil. He is involved in *all phases* of an oil well. A.I.M.E. members hold executive positions with their firms, and they have a decisive influence on *all* services and equipment. 13.8 per cent of A.I.M.E. members are geologists and geophysicists, and almost as many – 13.7 per cent – are oil company executives. Petroleum technology is their business, and *Petroleum Technology* is the magazine they read. If your product or service is technical, advertise it to the technical man – in the magazine technical men read.

IF YOUR PRODUCT IS TECHNICAL
ADVERTISE IT TO THE TECHNICAL MAN

JOURNAL OF PETROLEUM TECHNOLOGY IS PUBLISHED MONTHLY BY THE PETROLEUM BRANCH, AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS • DALLAS, TEXAS

JOURNAL OF
Petroleum Technology

Vol. V OCTOBER, 1953 No. 10

CONTENTS

Editorial Features — Section 1

News Briefs 7

Use of Chemicals for the Production of Oil, by W. H. Kirkpatrick 11

Technical Note: The Effect of Overburden Pressure on Relative Permeability, by I. Fatt 15

Technical Note: The Effect of Temperature on the Density and Electrical Resistivity of Sodium Chloride Solutions, by J. J. Arps 17

Use of Volumetric Methods in Reserve Estimation, reported by T. J. Nowak 21

Petroleum Transactions

A Method of Predicting Availability of Natural Gas Based on Average Reservoir Performance, by Ralph E. Davis and Lee Hilliard Meltzer 249

Gas Storage in the Playa Del Rey Oil Field, by John Riegle, Jr. 259

Volumetric Efficiency of Sucker Rod Pumps when Pumping Gas-Oil Mixtures, by C. A. Connally, C. R. Sandberg, and N. Stein 265

Institute Affairs — Section 2

Personals 2

Petroleum Branch Membership 3

Employment Notices 5

Book Reviews 6

Schedule of Local Section Meetings 7

Advertisers' Index 8

ON THE COVER

After all the geologists' reports are in and calculations of "where to drill" are made, one of an engineer's most gratifying moments comes. Below the derrick floor, the bit spurts drilling mud as it begins rotation and the spudding-in operation commences. This month's cover depicts that moment of beginning.

—Photo by Humble Oil & Refining Co.

the FIRST scratcher
B and W Scratchers and Centralizers for a Good Cement Job.
B and W Wall Cleaning Guide
B and W Nu-Coil Scratcher
B and W Multi-Flex Scratcher
B and W Rotating Scratcher
B and W Latch-On Centralizer with the New Kon-Kave Bow
FREE.. DON'T DELAY WRITE FOR YOUR RULER TODAY
First in the Field...
For a Good Cement Job!
B and W Inc.
Well Completion Specialists
GULF COAST
P. O. Box 5266
Houston 12, Texas
Phone WE-6603
WEST COAST
3545 Cedar Avenue
Long Beach 7, Calif.
Long Beach 4-8366

Remarkable well completion development

IMPROVED!

NEW DESIGN JET GUN

OLD DESIGN JET GUN

Johnston advanced design Expendable Jet Gun Reduces debris from perforating

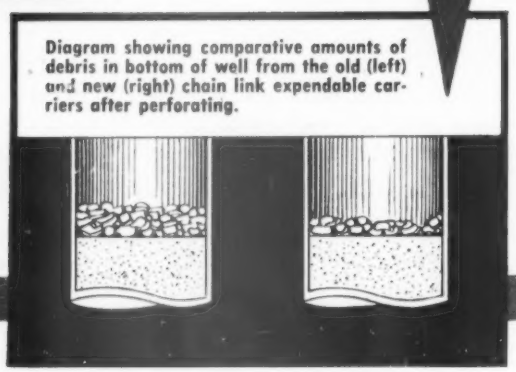


Diagram showing comparative amounts of debris in bottom of well from the old (left) and new (right) chain link expendable carriers after perforating.

Johnston Testers' engineering program has produced an advanced design of the Expendable Jet Gun used in their Shoot-Produce Method of well completion. A redesigned chain link expendable carrier and a 32 gram charge, manufactured by companies who specialize in this work, reduces the debris from perforation to about half that of the previous design.

This new Johnston Expendable Jet Gun makes possible as many as four shots per foot, and can be run in smaller diameter liners and casings.

The Johnston Shoot-Produce Method, which has made so many satisfied customers, has these definite advantages:

1. **COMPLETED HOOK-UP** – Christmas Tree and surface connections hooked-up before perforating.
2. **ELIMINATES ELECTRIC CURRENT PROBLEMS** – Hydrostatic pressure fires the Gun.
3. **SAVES RIG TIME** – Work-over equipment can be released immediately.
4. **NO SHOT HOLE PLUGGING** – Possible mud plugging of perforations can be eliminated.

WRITE FOR BOOKLET JPS ON PERFORATING

JOHNSTON TESTERS, INC.

POST OFFICE BOX 165 **HOUSTON, TEXAS**

EXPORT DIVISION: 3035 Andrita St., Los Angeles 65, California

SERVICE BRANCHES IN ALL ACTIVE AREAS

There's a Johnston Service Representative Near You

FORMATION AND CASING TESTING — JOHNSTON

News Briefs

Anglo-Iranian Oil Co. announces this month that 100 million tons of crude oil have poured from the Kirkuk Field of Northern Iraq since the first well came in as a gusher Oct. 24, 1927. Today, Kirkuk is still among the two or three greatest reservoirs in the world. The field is located some 500 miles from the nearest seaport. Production must be transported by means of a vast network of pipelines totalling more than 1,600 miles. The two Mediterranean sea terminals at Tripoli, Lebanon, and Banias, Syria, disperse 160,000 B/D and 280,000 B/D respectively.

* * *

More than 700 students with special abilities in science will be selected for a year of graduate scientific study during the academic year 1954-55 in the National Science Foundation's Third Annual Graduate Fellowship Program. Closing dates for receipt of applications are Dec. 15, 1953, for post doctoral applicants and Jan. 4, 1954, for graduate students working toward advanced degrees in science. Selections will be announced before April 1, 1954.

* * *

A total of 2,855 rigs are active in oilfields of the United States and Canada for the week ending Oct. 10, according to a report to the AAODC by Hughes Tool Co. This figure compares with 2,817 reported for the previous week, 2,819 a month ago, and 2,654 for the comparable week of 1952. Increases in rig activity were reported for Kansas, the Rocky Mountain states, West Texas and New Mexico, and the Gulf Coast and North Texas.

* * *

Dr. Gustav Egloff, director of research for Universal Oil Products Co. and recipient of many scientific awards, was in Japan early this month taking a leading role in the 75th anniversary celebration of the Chemical Society of Japan. He is the only American that was to address the society. As one of three invited foreign lecturers, he spoke on "The Platforming Process" and "Chemicals from Petroleum" at Tokyo and "Catalytic Reactions in Oil Refining" at Osaka during the week of the celebration. The other two foreign lecturers are Sir Robert Robinson of Oxford University, England, and Dr. Walter Reppe of Germany.

* * *

An unusual completion problem took Engineer Carl Schwab of Otis Pressure Control to Southwestern France this month. The well was drilled to a total depth of 12,000 ft. where a high pressure formation was encountered which produced a wellhead pressure of 7,000 psi and gas with a high percentage of hydrogen sulphide. The high pressure and presence of poisonous gas presented a problem for the French government-owned Societe Nationale Des Petroles D'Aquitaine. Schwab is supervising the French in the installation of various safety devices.

* * *

The ASTM announces that it now has available reprints of its "Review of ASTM Research" published in the December, 1952, and January and February, 1953, ASTM Bulletins. This material, prepared by the ASTM Administrative Committee on Research, summarizes the work of the various technical committees of the Society as of May, 1953. Copies of the 22-page pamphlet are available, without charge, at ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

* * *

Twenty fellowships totaling $40,800 have been given by Humble Oil and Refining Co. to be used at colleges and universities during the 1953-54 school year. The fellowships will enable students to do graduate work in geology, chemistry, physics, and petroleum, chemical, civil, and mechanical engineering and several non-technical curricula. Schools receiving the grants are Rice Institute, University of Texas, Texas A&M, University of Oklahoma, Louisiana State University, Georgia Institute of Technology, University of California at Los Angeles, Alabama Polytechnic Institute and Massachusetts Institute of Technology.

* * *

Wilbur L. Griffity, president of Canadian Prospects, Ltd. and managing director of Los Angeles Alberta Petroleum Ltd., announces that the estimated gas reserves in the 40,000 acres in Southeastern Alberta in which the above companies hold interest now are in excess of 50 billion cu ft. Recently, a test well one mile south of the discovery well Amurex-Denhart No. 1 encountered 40 ft of gas bearing formation.

* * *

Three sessions of the Fall General Meeting of the American Institute of Electrical Engineers, to be held in Kansas City's Hotel Muehlebach Nov. 2-6, will be devoted to electrical applications in petroleum refining and pipeline transmission of natural gas and oil. On Nov. 4, during a radio communication system session, W. M. Rust of the Humble Oil and Refining Co. will present a paper entitled "Use of Radio and Radar in the Petroleum Industry."

* * *

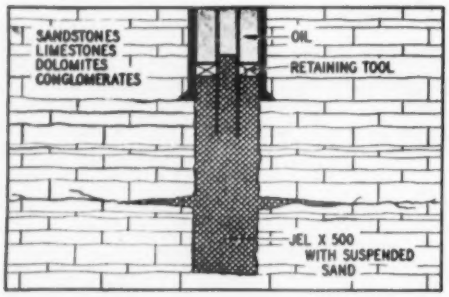
The first portable gas processing plants ever to be constructed in Western Canada will be built within the next few months by Canadian Palmer Stendel Oil Corp. as a result of agreements entered into with California Standard Co. (subsidiary of Standard Oil of California). Canadian Gulf Oil Co. (subsidiary of Gulf Oil Corp.) and others. Financing related to the project, estimated at approximately $1,000,000, is being arranged with the Chase National Bank and Consolidated Coppermines Corp.

* * *

Latest estimates compiled by the National Science Foundation indicate that obligations and expenditures of federal agencies for scientific research and development are expected to drop in fiscal year 1954 from the record totals of the past few years. Estimates of obligations for research and development are $2,074 million for 1954 compared to $2,187 million for 1953. Expenditures are estimated at $2,187 million in 1954, and $2,205 million in 1953. Since the lag between obligations and expenditures has averaged about nine months over the past several years, the decline in obligations for 1954 will presumably be reflected in a further decrease in expenditures in fiscal 1955.

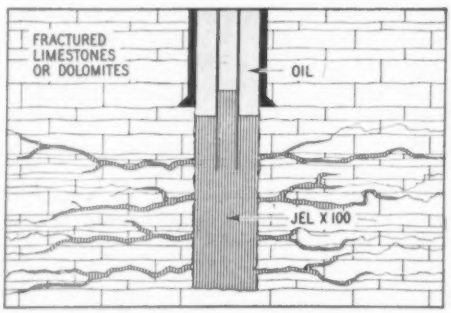
INCREASED OIL AND

Here are the Dowell Services using Jel X materials:



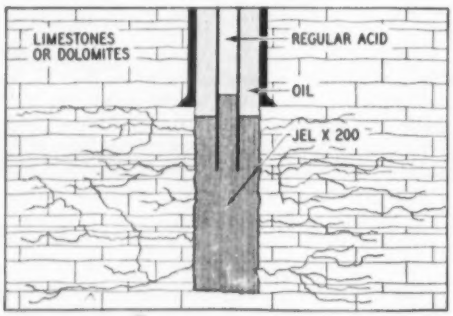
STRATAFRAC

This fracturing service using Jel X 500 has proved effective in limestone, dolomite, sandstone, and conglomerate formations. Stratafrac treatments are designed to dissolve soluble materials including silicates, paraffins and other heavy hydrocarbons and to open new fractures or extend old ones. They carry suspended sand into existing fractures as an abrading and propping agent. No jel-breaker solution is needed following a Stratafrac treatment.



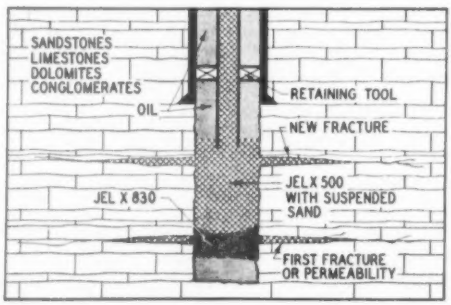
ETCHING ACID

This service utilizes Jel X 100 to permit greater penetration by the acid before it becomes spent. In formations normally requiring large amounts of regular acid, Etching Acid treatments have achieved comparable results with much less acid. They are designed to etch and enlarge "vugs", clean fractures by removing mud, silicate and feldspar materials, permitting better drainage.



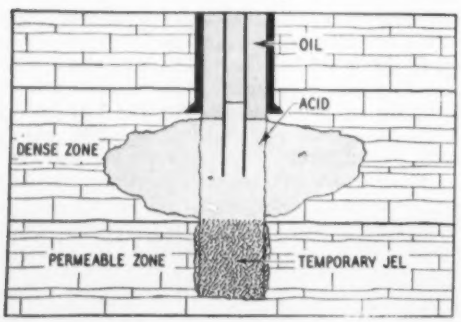
CHANNELING ACID

Channeling Acid Service uses Jel X 200 to form channels deep into pay formations. The acid in this case is mechanically diverted into a relatively few pores. This permits entrance of acid into zones far from the well bore, reaching production which might otherwise remain untapped. Channeling Acid treatments have proved particularly effective in retreating old wells.



FIXAFRAC

Fixafrac is a new temporary plugging service using Jel X 830. It is designed for use between stages of Dowell fracturing treatments to divert treating fluids into different sections. Jel X 830 carries suspended solids which react after treatment causing the material to liquefy and flow back freely to the well bore. No jel-breaker solution is needed following the treatment.



TEMPORARY PLUGGING SERVICES

These services utilize very viscous solutions (Jel X 700, 800, 820 and 900) which have proved effective in selective acidizing. They are designed to shut off the more permeable zones, permitting acid to be injected into tighter formations. Where increased plugging action is desired, the Jel X solutions can be prepared with suspended filler material. Temporary Plugging Services are particularly useful in wells having multiple zone completions.

GAS PRODUCTION WITH DOWELL JEL X

Dowell offers you newest improvements in chemical-mechanical treatments to improve oil and gas production

JEL X material in beaker at right is too thick to pass through ordinary window screen. After several hours it thins to free-flowing liquid at the left.

Results in many fields show that Dowell Services using Jel X materials have improved the producing characteristics of all types of formations.

These services operate both mechanically and chemically, and may provide fracturing, acidizing or a combination of both in a single treatment. Results of Dowell treatments have shown excellent production increases in formations that were previously unresponsive to regular acidizing.

A big, worthwhile advantage of the Dowell Services that use Jel X is the speed of treatments. Non-productive rig-time is held to a minimum with treatments often requiring as little as a few hours time. What is more, time-consuming mixing of chemicals on location has been largely eliminated. Costly shut-in time after treatment is unnecessary.

FREE, FACT-FILLED LITERATURE

Your nearest Dowell station can give you complete details on these important new well treating services. Or drop us a letter in Tulsa to Dept. J-15 for the latest literature.

DOWELL SERVICE

Acidizing • Fracturing • Electric Pilot • Perfojet
Paraffin Solvents • Bulk Inhibited Acid • Jelflake®
Corban® • Chemical Cleaning for Heat Exchange Equipment

DOWELL INCORPORATED • TULSA 1, OKLAHOMA
A Subsidiary of The Dow Chemical Company

"First in Oilfield Acidizing . . . Since 1932"

Look to **DOWELL**

FOR OIL INDUSTRY CHEMICAL SERVICE

We Insist on the BEST!

From Precision Roller Bearings, High Strength Cast Iron, and Tough Alloy Steel, to the final coat of paint, our inspectors and metallurgists keep a constant vigil to make doubly sure that only the FINEST MATERIALS go into the manufacture of . . .

LUFKIN

Quality Products

SEE OUR CATALOG IN THE COMPOSITE CATALOG

Lufkin FOUNDRY & MACHINE COMPANY

LUFKIN, TEXAS

Branch sales and service Houston, Dallas, New York, Tulsa, Los Angeles, Seminole, Oklahoma City, Corpus Christi, Odessa, Kilgore, Wichita Falls, Casper, Wyoming, Great Bend, Kansas.

Lufkin Equipment in CANADA is handled by

THE LUFKIN MACHINE CO., LTD., 14321 108th Avenue, Edmonton, Alberta, Canada.

Use of Chemicals for the Production of Oil

By W. H. Kirkpatrick
Assistant Vice-President
Visco Products Co.

Crude petroleum is one of the two great natural liquid resources serving mankind as a lubricant, as a fuel and more recently as a chemical raw material. Like water, the other important natural liquid resource, crude oil must be conditioned before its maximum utility can be fully exploited by industry. Unlike water, much of the conditioning of crude oil must occur as it is being produced.

Today the oil industry is producing about 7 million bbls of crude oil daily and it is estimated that an equal volume of water is brought to the surface with the oil. It is this co-production of water and oil which brings grief to the oil production personnel.

It is inevitable when two crude, impure immiscible liquids are brought in intimate contact that some degree of emulsification will occur. By definition an emulsion is a mixture of two insoluble liquids in which one liquid is dispersed throughout the other. It follows that two types of emulsion may occur; namely, oil dispersed in water and water dispersed in oil. Crude oil emulsions are predominantly of the water-in-oil type and only in isolated areas of California, Texas, and Wyoming can oil-in-water emulsions be found.

The practical problem of resolving crude oil emulsions brings up consideration of the theory of demulsification. Unfortunately, these theories are as diverse as the emulsions they concern and no one theory is equally applicable to all emulsions. The most widely accepted explanation is that the interfacial surface between the dispersed phase and the continuous phase is modified. But at this point all agreement ceases. It is generally recognized that the liquid having the greater surface tension will form the inner or dispersed phase. Hence a change in the surface tension of either phase could result in resolution provided that the surface tension lowering was stopped short of the point of reversing the emulsion. This is exemplified by the fact that a material that will act as an emulsifier for an oil-in-water emulsion will sometimes act as a demulsifier for a water-in-oil emulsion. This is known as the counter-colloid principle.

Other schools of thought postulate that the emulsifier is rendered inactive by the addition of the demulsifier through neutralization, change in *pH*, or loss of solubility. Others suggest that the film or envelope surrounding the dispersed globules is contracted and rigidified by the emulsion breaker and shatters, permitting the globules to coalesce and stratify. Still others believe that the emulsifying agents are polar bodies and function because of their electronic fields and any disturbance of these fields by electron-carrying molecules will result in breaking of the emulsion.

Origin of Demulsifiers

In the early days, crude oil emulsions were broken by mechanical means. At first, water was driven away by heat but this was found too costly and hazardous as all the light ends were lost with the steam. Other mechanical methods such as centrifuging and electric treatment proved unsatisfactory from an economical standpoint. Some of the venturesome oil field pioneers who experimented with almost every material at their disposal gave birth to the chemical demulsifying art.

Today we know that a successful demulsifier must be a large molecule possessing both hydrophilic and hydrophobic characteristics within the same molecular structure. This is usually accomplished by starting with an oil soluble molecule and by synthesis water soluble groups are introduced until the desired hydrophobe-hydrophile balance has been attained. This knowledge has been acquired slowly over the years in the evolution of treating chemicals from the early use of caustic soda to today's modern, efficient and economical chemicals.

The first commercial treating chemical was a solution of a cheap soap chemically equivalent to Gold Dust Cleanser, a product familar to our grandmothers. From this basic idea, chemists investigated most of the soap-forming materials running from the simple fatty acids to the complex acids derivable from marine, vegetable or mineral oils. Simultaneously, most of the known saponification reagents were used to prepare the less common soaps of these fatty bodies. As a group, the soaps had one common disadvantage and that was their water softening action to yield insoluble soaps that frequently stabilized emulsions.

The more effective soaps were derived from unsaturated fatty acids although it was observed that triricinolein or castor oil soaps were good. This led to the investigation of the entire field of addition to the reactive double bonds in the unsaturated fatty bodies. Since castor oil is a hydroxylated fatty body, first attention was directed to oxidation of the double bond by blowing with moist air under elevated temperatures and pressures.

Simple addition of halogens and the like to the double bond was to no avail. However, the additions of the sulfo- or the sulfonic group led to surprising and gratifying results. These sulfonated oils were already articles of commerce being used in the textile industry as aids in dyeing and being known as Turkey Red Oil. A vast number of these compounds was already available for testing and only a short time was required to determine the most effective structure.

Sulfonation Reactions

Up to this stage, development had been concerned with relatively simple molecules but with the success of sulfonic acid derivatives, the whole field of sulfonation reactions was opened up, permitting a large variety of molecular structures and combinations to be studied. This work led to two very important types of demulsifiers commonly known as Twitchell agents and Walker reagent. The Twitchell agents were regularly used as fat-splitters in the soap industry to hydrolyze fatty materials in the manufacture of soap and glycerine. Chemically, they are the reaction product of sulphuric acid,

an aromatic hydrocarbon and an unsaturated fatty acid to yield a relatively complex substituted sulfo-fatty acid.

Demulsifiers of the Walker type are still being used as commercial crude oil demulsifiers in very limited quantities. This type of chemical is almost universal in its demulsifying action but the efficiency is very low. For this reason the customary slugging compound used in pipeline centrifuge grindouts is of this formula type.

The Walker reagent is an alkylated aromatic sulfonic acid salt which affords the chemist the opportunity of varying the alkyl groups, the aromatic nucleus and the saltforming group in order to secure the optimum demulsification characteristics. It might be interesting to note that a simple aromatic sulfonic acid is without action but with the addition of alkyl groups to the molecule demulsifying action appears. This can be explained by the hydrophobe-hydrophile balance theory in that the unsubstituted sulfonic acid is extremely hydrophilic and the hydrophobicity is introduced with the alkyl groups.

The next stage of development of demulsifiers involves the resin field and in particular the phenol-formaldehyde type and alkyd type. It is obvious that the insoluble, infusible resins of commerce could not be used for demulsification but by modification of manufacture or by introducing other reactive materials products can be secured which are liquid and sufficiently soluble or dispersible in crude oil fluids to be effective.

The so-called modified Bakelite resins, or phenol formaldehyde, find very limited application. On the other hand the alkyd or glyptal type resins have been used extensively in every oil field. These reaction products of a polyhydroxy body and a polybasic acid give chemists an almost infinite number of variations to investigate. Of course economic considerations impose certain limitations on the extent of all development research. The basic nucleus for most of the alkyd compositions is phthalic anhydride and castor oil. Some variation is secured by the condition of reaction but predominantly the formulations vary in the nature and kind of modifying agent employed. By the use of amines, fatty oils, glycols and the like, the hydrophobe-hydrophile balance may be varied at will.

Growth of Treating Chemicals

Not many years ago it was the considered opinion of several experts in our industry that no efficient demulsifier could be developed without using castor oil as a raw material. Wartime shortages of castor oil and intensive research have confounded the experts, for today castor oil-derived compounds are by far in the minority. Taking the place of castor oil is a class of compounds which permit practically a tailor-made composition of any design or characteristic. Since most of this work is currently in progress, we are not at liberty to disclose any of the details.

Tremendous advances in oil treating chemicals have been made during the past 20 years. For example, as late as the 1930's oil treating costs in the Cayuga, Texas, Field averaged about 12 cents per bbl, whereas today the treating costs are figured in mils per bbl. An incidental plus had also been gained during these years for today's compounds can be handled with ease as compared to yesterday's sticky, tenacious material which almost defied removal from hands, tools, and clothing. To show further the rapid progress of developments, upwards of 75 per cent of the commercial demulsifiers offered by progressive companies today were unthought of by research men as little as five years ago. This by no means should be construed to indicate that a new demulsifier can be conceived and built overnight, but on the contrary a major development may require many years before full fruition may be attained.

Although demulsifying chemicals currently constitute the major portion of the oil treating chemical market a few words should be devoted to chemicals for corrosion control, paraffin control, scale control, and additives for various treatments for improving recovery and water disposal.

Corrosion inhibiting chemicals are for the most part semi-polar nitrogen-containing molecules which possess the property of forming monomolecular protective films on metal surfaces which are impervious to the attack of corrosive agents found in well fluids. Inorganic chromates are also used and depend on film formation for the protection they afford. The property of inorganic alkalis to neutralize acidic corrosive agents is employed to a limited degree.

Chemicals available for correction of paraffin problems fall into two classifications: paraffin solvents and paraffin inhibitors. In general, paraffins are soluble in straight chain hydrocarbons, chlorinated hydrocarbons, carbon bisulfide, etc., but concentrations of solvents required to effect solution usually are prohibitive for economic oil field use. The paraffin inhibitors are for the most part alkylated naphthalene derivatives which are absorbed at the paraffin crystal surfaces preventing further crystal formation so that the original particle remains mobile and capable of flowing with the balance of the fluid.

The agents used for controlling scale formation and build-up are quite diverse but all rely on the property of sequestering the calcium and magnesium ions, thus preventing the deposition of salts of these ions.

Acidizing Control

All of the services offered for increasing the productivity of oil wells are dependent for their success to a greater or lesser degree on chemical additives. Most of these services have a common purpose in enlarging the formation fissures so that greater quantities of oil may reach the bore hole. In limestone formations hydrochloric acid is often used and chemicals are added to prevent emulsification and to lower surface tension on the virgin acid as well as the spent acid to facilitate the removal of the depleted acid solution. Special problems are presented in the development of these chemicals because solubility in hydrochloric acid is essential.

Several services are offered in which the formation is fractured with hydraulic pressure and the resulting enlargement of the fissures is supported by sand granules. In one service the sand is suspended in a jelled kerosene or distillate produced by adding a fatty acid soap to the hydrocarbon. After the viscous fluid is pumped in place and held for a period of time, an aliphatic amine is pumped down the hole where it acts as a jel breaker to permit the fluid to return to the well bore, leaving the sand in place. High bottom hole temperature will lower the viscosity to a point where the suspended sand will be dropped and hence should be avoided. Another service that is not limited to bottom hole temperatures depends on carrying the sand with an emulsion of kerosene and hydrochloric acid. When pumped in place the acid is slowly neutralized by the formation and the emulsion is broken into its components which are removed with resultant oil flow.

Our industry faces the future with supreme confidence that we can meet any and all challenges presented by the technological advances of the very progressive and far-sighted oil industry. We have the productive facilities, we have the service personnel, we have the research personnel and, above all, we have the experience and know how. ★ ★ ★

The world's deepest well was drilled with

Black Magic

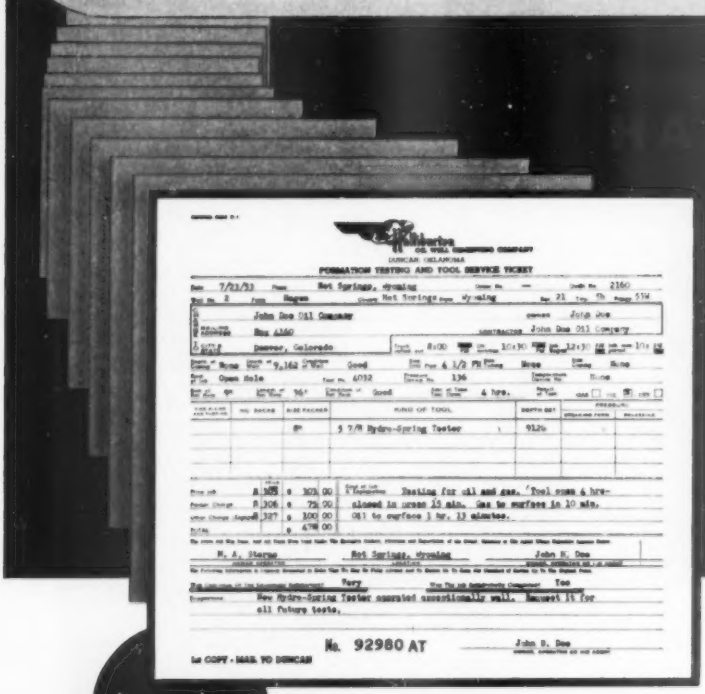
Two of the three deepest wells in the world were drilled with Black Magic. At 10,955′ in Ohio Oil's record-breaking well at Paloma, Black Magic replaced the clay water mud and was used from that point to the world's new record. On September 1, 1953, the well was drilling below 20,650′. At no time was any trouble encountered which could be attributed to the mud. From Ohio Oil's report, "... use of the oil base mud is believed to have reduced fishing jobs to a minimum." Black Magic was unaffected by the high temperature (Bottom Hole temperature at 20,003′ was 334°F).

The low viscosity of Black Magic permitted lower pump pressure. "At 20,000′ the Ohio Oil Company's deep test was still able to break circulation of the mud with pump pressures of 800 p.s.i. and while drilling at this depth pump pressures were not needed beyond 1,700 p.s.i." Black Magic was weighted to 85 lbs. cu. ft. (11.3#/gal.) at the start but increased to 125 (16.7#/gal.) to kill a salt water flow. Maintenance time was negligible and cost extremely low despite the high flow line temperature which reached 175°F. Accurate electric and radiation logs were obtained at 20,003′. For deep well drilling, switch to Black Magic. Contact your Oil Base representative for details.

OIL BASE, Inc. 130 ORIS STREET, COMPTON, CALIFORNIA

Bakersfield, Long Beach, Ventura, Newhall, Houston, Fort Worth, Oklahoma City, Midland, Odessa, Jennings, Caracas, Paris

A YEAR OF USE with PERFECT SUCCESS!


DUNCAN, OKLAHOMA
FORMATION TESTING AND TOOL SERVICE TICKET
John Doe Oil Company
Box 4160
Denver, Colorado
Open Hole
5 7/8 Hydro-Spring Tester
Testing for oil and gas. Tool open 4 hrs-
closed in screen 10 min. Gas to surface in 10 min.
Oil to surface 1 hr. 17 minutes.
No. 92980 AT
John D. Doe
1st COPY - MAIL TO DUNCAN

Hydro-Spring TESTER

Hydro-Spring Patent Applied For

Results with this revolutionary testing tool have exceeded the highest hopes of the industry.

Released for exploratory field testing in June, 1952, Hydro-Spring Tester gained rapid recognition. Since that time, it has established a perfect record – not one mis-run in more than 2000 tests – *under all conditions.*

Unusual features that enabled this Halliburton testing tool to establish its remarkable record include:

- **Locked open bypass that squeezes packer through tight holes, doing away with undue spudding, drill pipe manipulation, and surging pressures on the recording chart.**
- **Opens easily and positively by weight of drill pipe, eliminating rotating, dropping of bar, turning of J-slots.**
- **Provides positive indication at surface that tool is open.**
- **Permits reversing off bottom simultaneously with taking closed-in pressure.**
- **Can be rotated coming out of hole.**
- **Requires fewer assemblies.**

If you've waited for Hydro-Spring to prove itself – here's all the proof you need. So, take advantage of these successful features on your next test. Phone your nearby Halliburton Testing Operator. Or contact Halliburton Oil Well Cementing Company, Duncan, Oklahoma.

YEARS AHEAD IN DRILL STEM TESTING!

HALLIBURTON

Technical Note 194 –

THE EFFECT OF OVERBURDEN PRESSURE ON RELATIVE PERMEABILITY

I. FATT, CALIFORNIA RESEARCH CORP., LA HABRA, CALIF.

Laboratory relative permeability data on reservoir rock are obtained on samples which are not subjected to overburden pressure during the permeability measurements. These data are then used for calculating the performance characteristics of reservoirs in which the rock is under the pressure of the overburden. Recent observations have shown that the permeability and porosity of reservoir sandstones are decreased by application of overburden pressure.[1,2] These observations led us to a study of the effect of overburden pressure on the relative permeability characteristics of sandstones.

A previous note from this laboratory[1] showed that overburden pressure, simulated by applying hydraulic pressure to the outside of a plastic mounted core, caused a reduction in permeability of the core by as much as 50 per cent at 10,000 psig. In a multiphase fluid flow system, the relative permeability at a given saturation will change if the permeability or the effective permeability changes but not if both permeability and effective permeability change by the same ratio. The tests described in this note were made to determine the effect of overburden pressure on permeability and effective gas permeability in the gas-oil system. The gas-oil system was chosen because the available equipment was best suited for studying this system. The resultant data can be applied to other systems of interest because the gas permeability in the gas-oil system is the permeability of the nonwetting phase and, as such, is equivalent to the gas permeability in the gas-oil-water system and to the oil permeability in the oil-water system.

EXPERIMENTAL METHOD

Cylindrical test plugs, one in. in diameter and one in. long, were cut from sandstone core samples from three different reservoirs. After extraction in toluene, the plugs were mounted in Lucite by conventional core mounting methods.[3] The core properties are given in the legend in Fig. 1. The mounted cores were machined to fit the apparatus shown in Fig 4. Air permeabilities as a function of overburden pressure were measured by connecting lines (1) and (2) to a conventional air permeameter. To measure porosity changes as a function of overburden pressure, the lines leading to (1) and (2) and the core were saturated with kerosene; line (1) was capped and a small bore precision calibrated pipet was connected to (2). Changes in pore volume of the core as overburden pressure was applied were noted by reading the amount of kerosene produced into the pipet. To correct for the change in volume of the lines inside the hydraulic cell as a function of pressure, a pressure-*vs*-volume run was made with a solid Lucite cylinder substituted for the core. The change in volume of the lines was about 10 per cent of the change in pore volume of the core. No correction was needed for the permeability measurements because there was no measurable pressure drop in the lines at the maximum overburden pressure.

Relative gas permeabilities were measured by the stationary liquid method described by Osoba, *et al.*[4] Gas saturations were obtained by allowing the kerosene from a kerosene saturated core to evaporate out. This procedure was followed

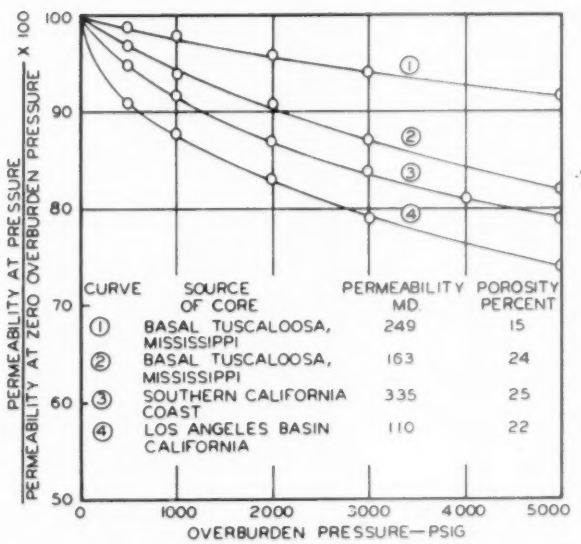


FIG. 1 — CHANGE IN PERMEABILITY WITH OVERBURDEN PRESSURE.

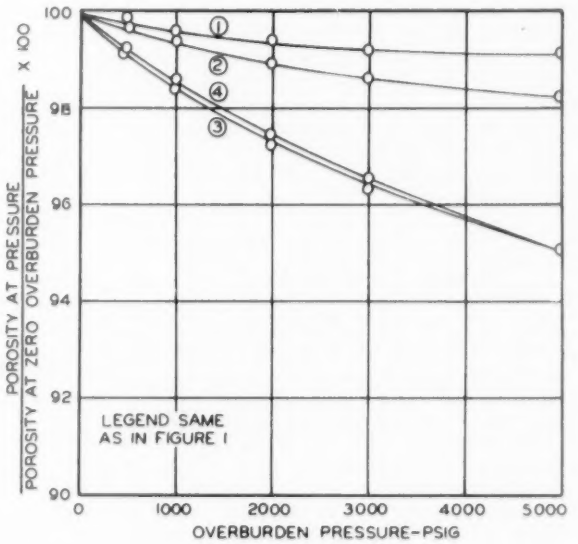


FIG. 2 — CHANGE IN POROSITY WITH OVERBURDEN PRESSURE.

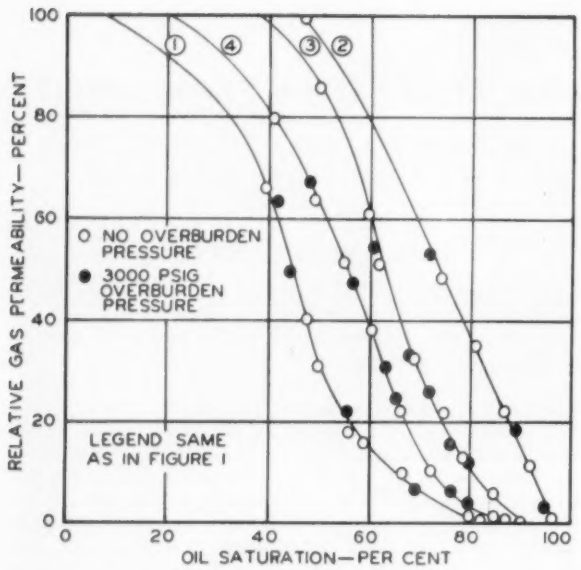


FIG. 3 — RELATIVE GAS PERMEABILITY IN THE GAS-OIL SYSTEM WITH AND WITHOUT OVERBURDEN PRESSURE.

for cores with and without overburden pressure. Evaporation from cores in the overburden pressure cell was speeded by inserting hypodermic tubing through line (1) until it touched the core face and then flowing a very gentle stream of air through the tubing. Gas saturations were established with the core under overburden pressure. If the gas saturation was established at surface conditions and then overburden pressure applied, a lower effective gas permeability was observed. The difference can be attributed to a hysteriesis effect. Application of overburden pressure reduced the pore volume which in turn decreased the gas saturation because capillary forces held the oil volume in the core constant. Relative gas permeabilities in the gas-oil system measured with decreasing gas saturation are usually lower, at a given gas saturation, than relative gas permeabilities measured as gas saturation is increased. The relative gas permeabilities presented in Fig. 3 were measured as gas saturation increased.

Relative gas permeabilities were calculated by dividing the measured effective gas permeability by the permeability of the core at the overburden pressure of the test. Gas saturations were calculated from the weight of the core after the effective gas permeability measurement. The gas saturation was given by:

$$S_g = 100\,\frac{(V_p - \frac{1}{\rho}(W_s - W_D)}{V_p}$$

where S_g is the gas saturation in per cent, V_p is the pore volume of the core at overburden pressure of the test, ρ is the density of the oil phase, W_s is the weight of the partially saturated core after the effective gas permeability measurement, and W_D is the weight of the dry core.

The internal pressure in the core was always atmospheric; the overburden pressure was the hydraulic pressure of the fluid surrounding the core. Calculation of the stress transmitted to the core through the Lucite jacket showed that the stress on the core was within about one per cent of the hydraulic pressure on the jacket. The elastic constants of Lucite required in this calculation were measured in this laboratory; the elastic constants of the rock were taken from the Handbook of Physical Constants.[5]

RESULTS

Data from four sandstone cores, shown graphically in Fig 3, indicate that the relative gas permeability characteristics, at 3,000 psig overburden pressure, are not affected by overburden pressure in this pressure range. These results are probably representative of the nonwetting phase behavior of any multiphase fluid flow system. Although the stress conditions existing in the reservoir may not be exactly duplicated in these tests, the difference between reservoir and laboratory stress conditions is not enough to affect the results.

The reduction in permeability as a function of overburden pressure is shown graphically in Fig. 1. Porosity reductions are shown in Fig. 2. The porosity changes are negligible because the changes are smaller than the uncertainty in averaged core porosities. When reservoir calculations require accurate permeabilities, the reduction in permeability with overburden pressure may be large enough to warrant consideration.

These results lead to the conclusion that laboratory nonwetting phase relative permeability data obtained on core samples are not in error because of the absence of overburden pressure. When used in reservoir calculation requiring great accuracy, the effective permeability should be obtained by multiplying the relative permeability by the permeability at the overburden pressure calculated for the reservoir. The overburden pressure on rock buried in the earth is approximately 0.56 psi per foot of depth, based on the assumption of an overburden consisting of sandstone and shale (of assumed average specific gravity 2.3) and a liquid pressure resulting from a water column (of specific gravity 1.0) reaching from the rock to the surface of the earth.

REFERENCES

1. Fatt, I., and Davis, D. H.: "Reduction in Permeability with Overburden Pressure," *Trans.*, AIME, (1952) **195**, 329.
2. Carpenter and Spencer, "Measurement of Compressibility of Consolidated Oil Bearing Sands," U. S. Bureau of Mines, R. I. 3450 (1940).
3. Showalter, W. E.: "Mounting Core Analysis Specimens in Thermo-Plastics," *Jour. Pet. Tech.*, (December, 1950).
4. Osaba, J. S., *et al.*: "Laboratory Measurements of Relative Permeability," *Trans.* AIME, (1951) **192**, 47.
5. "Handbook of Physical Constants," Geological Society of America, Special Paper No. 36, Edited by F. Birch, J. F. Schairer, and H. C. Spicer, (1942).

★ ★ ★

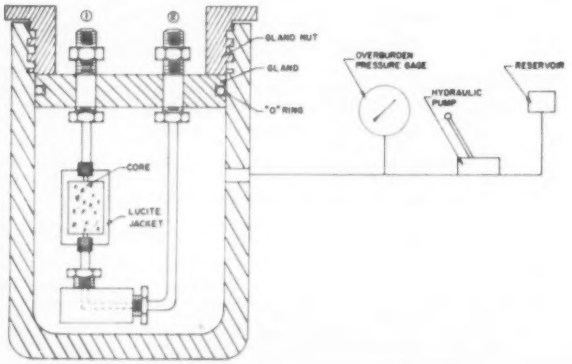


FIG. 4 — DIAGRAMMATIC SKETCH OF EXPERIMENTAL EQUIPMENT.

Technical Note 195—

THE EFFECT OF TEMPERATURE ON THE DENSITY AND ELECTRICAL RESISTIVITY OF SODIUM CHLORIDE SOLUTIONS

J. J. ARPS, THE BRITISH-AMERICAN OIL PRODUCING CO., DALLAS, TEXAS, MEMBER AIME

ABSTRACT

This paper is a study of the effect of temperature on the electrical resistivity of sodium chloride solutions based on the published resistivity and density data in the *International Critical Tables*. This temperature effect is of considerable importance in quantitative interpretation of electric logs, where it is frequently necessary to correct mud resistivities measured under surface conditions to temperatures existing at the bottom of the bore hole. An empirical approximation formula was developed for this conversion which has proved to be very useful and seems to provide results well within the range of accuracy of the data involved. This approximation formula states:

$$(R_w)_{t_2} = (R_w)_{t_1} \frac{t_1 + 7}{t_2 + 7}, \text{ where}$$

$(R_w)_{t_1}$ and $(R_w)_{t_2}$ are the electrical resistivities of sodium chloride solutions at temperatures of t_1 and t_2 degrees Fahrenheit, respectively.

INTRODUCTION

Research by various investigators[1,2,3] during the past 20 years has clarified the physical principles of the phenomena which cause the natural or spontaneous electric potential in rotary drilled bore holes. The basic relationship which is most commonly used reads:

$$SP_{cor} = -K \log_{10} \frac{R_{mf}}{R_w} \quad . \quad . \quad (1)$$

in which the *SP* deflection, as measured from the shale base line, is expressed in millivolts. K is a constant, which appears to vary between 50 and 110; the low value applying to shaly sands, whereas the higher values are more common in carbonate rocks. A good average value for $K = 70$, for which value there is considerable theoretical justification.[1]

In order to calculate the resistivity of the connate water R_w and to estimate its "equivalent salinity" (as NaCl) from an electric log by means of this *SP* relationship from a knowledge of the static self potential and of the resistivity of the mud filtrate R_{mf}, it is necessary to first correct the resistivity of the mud filtrate measured under surface conditions to the resistivity of this same mud filtrate in the well bore at a different temperature.

In order to make this temperature conversion for the mud filtrate the variation of the electrical resistivity of sodium chloride solutions with temperature is commonly used. Since some discrepancies were found in the charts ordinarily used for this purpose, it was felt desirable to make a new study of this relationship based on the published measurement data. Because of the fundamental nature of these relationships and as an aid to other workers in this field, an attempt has been made in this study to show every step in the calculations.

CONDUCTIVITY *VS* MOL CONCENTRATION

The most complete published reference on the temperature relationship of sodium chloride solutions of different concentrations is provided in the *International Critical Tables*.[4] The basic measurement data on the electrical conductivity of aqueous sodium chloride solutions, at different temperatures, as given in these tables, are reproduced in Table 1.

The electrical conductivity values $\wedge$ in this Table 1 are expressed as 10^6 times the specific conductivity k in ohm^{-1}cm^{-1} per unit of concentration in milligram mols per liter of solution C_i or:

$$\wedge = 10^6 \frac{k}{C_i} \quad . \quad . \quad . \quad . \quad . \quad . \quad (2)$$

RESISTIVITY *VS* MOL CONCENTRATION

These conductivity values from Table 1 were first converted to the corresponding electrical resistivity values $(R_w)_t$, expressed in ohm-meters, as is conven-

Table 1* — Electrical Conductivity $\wedge$ of Aqueous Sodium Chloride Solutions as a Function of Concentration C_i and Temperature t.
(Expressed as 10^6 times the specific conductivity in ohm^{-1}cm^{-1} per unit of concentration in milligram mols per liter of solution)

Concentration (C_i) (milligram mols per liter of solution)	TEMPERATURE IN DEGREES FAHRENHEIT t						
	32°	64.4°	77°	122°	212°	284°	312.8°
0.1	....	107.88	....	....	....	....	....
0.2	....	107.60	....	....	....	....	....
0.5	....	106.95	125.0	....	354.9	491	545
1	65.8	106.27	124.12	195.3	352.5	....	....
2	65.2	105.31	123.03	193.6	348.5	481	534
5	64.2	103.54	120.88	190.1	341.9	....	....
10	63.2	101.72	118.63	185.6	335.0	461	511
20	61.7	99.40	115.85	179.9	325.4	....	....
50	59.5	95.51	111.08	170.8	309.7	....	....
70	58.7	....	109.01	167.1	303.2	....	....
80	....	....	....	....	....	411	540.5
100	57.7	91.82	106.66	163.4	295.6	403.5	441.5
200	55.6	87.53	101.55	155.6	287.9	....	....
500	51.8	80.76	93.31	141.9	274.4	....	....
700	49.9	....	....	....	263.6	....	....
1,000	47.5	74.19	....	....	247.5	....	....
2,000	41.4	64.66	....	209.7**	....	....	....
3,000	36.5	56.4	....	184.1**	....	....	....
4,000	31.5	42.6	....	164.6**	....	....	....
5,000	26.6	....	44.7	....	....	....	....
5,500	24.6	....	....	....	....	....	....

*Data from Ref. 2.
**Probably erroneous, should be for 212° F.

Table 2 — Specific Gravity g_t or Density (g/cc) of Aqueous Sodium Chloride Solutions as a Function of Sodium Chloride Weight Percentages and Temperatures t.

Percent NaCl by weight	TEMPERATURE IN DEGREES FAHRENHEIT t						
	32°	64.4°*	77°	122°	212°	284°**	312.8°†
1	1.00747	1.00569	1.00409	0.99482	0.9651	0.9258	0.9179
2	1.01509	1.01285	1.01112	1.00161	0.9719	0.9323	0.9244
4	1.03038	1.02728	1.02530	1.01531	0.9855	0.9455	0.9375
6	1.04575	1.04183	1.03963	1.02919	0.9994	0.9588	0.9507
8	1.06121	1.05653	1.05412	1.04326	1.0134	0.9723	0.9640
10	1.07677	1.07138	1.06879	1.05753	1.0276	0.9859	0.9775
12	1.09244	1.08642	1.08365	1.07202	1.0420	0.9997	0.9912
14	1.10824	1.10166	1.09872	1.08674	1.0565	1.0137	1.0051
16	1.12419	1.11708	1.11401	1.10170	1.0713	1.0278	1.0191
18	1.14031	1.13281	1.12954	1.11691	1.0864	1.0423	1.0334
20	1.15663	1.14874	1.14533	1.13238	1.1017	1.0569	1.0479
22	1.17318	1.16494	1.16140	1.14812	1.1172	1.0718	1.0627
24	1.18999	1.18143	1.17776	1.16414	1.1331	1.0870	1.0777
26	1.20709	1.19824	1.19443	1.18045	1.1492	1.1024	1.0930

*Interpolated between $g_{32}°$ and $g_{77}°$.
**0.92085 x $g_{32}°$.
†0.91301 x $g_{32}°$.

Table 3—Concentration C_t of Aqueous Sodium Chloride Solutions in Milligram Mols per Liter of Solution as a Function of Sodium Chloride Concentration by Weight (ppm) and Temperature t.

(ppm) Parts per Million by Weight (mg NaCl per Kg solution)	TEMPERATURE IN DEGREES FAHRENHEIT t						
	32°	64.4°	77°	122°	212°	284°	312.8°
10,000	172.364	172.059	171.786	170.200	165.115	159.623	157.038
20,000	347.336	346.570	345.978	342.724	332.558	321.603	316.300
40,000	705.136	703.014	701.660	694.823	674.423	652.121	641.560
60,000	1,073.482	1,069.460	1,067.119	1,056.482	1,025.902	991.966	975.901
80,000	1,452.469	1,446.050	1,442.765	1,427.901	1,387.032	1,341.192	1,319.470
100,000	1,842.207	1,832.989	1,828.554	1,809.290	1,758.084	1,699.972	1,672.441
120,000	2,242.819	2,230.460	2,224.773	2,200.896	2,139.264	2,068.508	2,035.008
140,000	2,654.466	2,638.711	2,631.664	2,602.969	2,530.538	2,447.025	2,407.394
160,000	3,077.338	3,057.875	3,049.471	3,015.775	2,932.558	2,835.620	2,789.696
180,000	3,511.647	3,488.538	3,478.481	3,439.585	3,345.629	3,234.914	3,182.523
200,000	3,957.673	3,930.676	3,919.008	3,874.696	3,769.718	3,644.808	3,585.778
220,000	4,415.732	4,384.725	4,371.393	4,321.409	4,205.029	4,065.736	3,999.889
240,000	4,886.182	4,851.051	4,835.965	4,780.040	4,652.588	4,498.033	4,425.185
260,000	5,369.434	5,329.284	5,313.119	5,250.932	5,111.925	4,942.098	4,862.059

tional in electric logging practice. Since $(R_w)_t$ by definition equals $\frac{1}{100\,k}$ and since, according to Equation 2, $k = 10^{-6} \wedge C_t$, the conversion can be made from the data of Table 1 with the relationship:

$$(R_w)_t = \frac{10^4}{C_t \times \wedge} \quad . \quad . \quad . \quad . \quad (3)$$

The results of this conversion are presented in Table 4, which shows this resistivity $(R_w)_t$ as a function of concentration C_t and temperature t. It also shows the corresponding ppm (parts per million) values which, however, were arrived at in a different manner, as will be discussed hereafter.

SPECIFIC GRAVITY *VS* MOL CONCENTRATION

We now have a relationship which provides the electrical resistivity of a solution of a given weight of sodium chloride in a given volume of solution. This volume of solution, however, depends in turn on the concentration of sodium chloride by weight and on the temperature, and it is therefore necessary first to establish the relationship between concentration in parts per million and specific gravity for various temperatures. The required data for this conversion were also obtained from the *International Critical Tables*.[5] They are reproduced in Table 2, which shows specific gravity g_t or density in grams per cubic centimeter at various temperatures t for different concentrations expressed as weight percent NaCl. The

Table 4 — Electrical Resistivity $(R_w)_t$ of Aqueous Sodium Chloride Solutions in Ohm-meters for Various Temperatures t as a Function of Sodium Chloride Concentration C_t or as Parts per Million by Weight.

Concentration (C_t) (milligram mols per liter of solution)	TEMPERATURE IN DEGREES FAHRENHEIT (t)													
	32°		64.4°		77°		122°		212°		284°		312.8°	
	ppm	Res.	ppm	Res.	ppm	Res.	ppm	Res.	ppm	Res.	ppm	Res.	ppm	Res.
0.1	—	—	5,812	926.96	—	—	—	—	—	—	—	—	—	—
0.2	—	—	11,624	464.68	—	—	—	—	—	—	—	—	—	—
0.5	—	—	29,060	187.00	29,106	160.00	—	—	30,282	56.353	31,324	40.733	31,839	36.697
1	58,017	151.97	58,120	94.100	58,212	80.56	58,754	51.203	60,564	28.392	—	—	—	—
2	116,03	76.687	116,24	47.479	116,42	40.64	117,51	25.826	121,13	14.347	125,30	10.395	127,36	9.3633
5	290,08	31.152	290,60	19.316	291,06	16.545	293,77	10.521	302,82	5.849	—	—	—	—
10	580,17	15.822	581,20	9.831	582,12	8.430	587,54	5.388	605,64	2.985	626,48	2.1690	636,79	1.9569
20	1,160,3	8.1037	1,162,4	5.030	1,164,2	4.316	1,175,1	2.779	1,211,3	1.536	—	—	—	—
50	2,900,8	3.361	2,906,0	2.0940	2,910,6	1.801	2,937,7	1.171	3,028,2	0.6458	—	—	—	—
70	4,061,2	2.434	—	—	4,074,8	1.310	4,112,8	0.8549	4,239,5	0.4711	—	—	—	—
80	—	—	—	—	—	—	—	—	—	—	5,011,8	0.30414	5,094,3	0.24950
100	5,801,7	1.733	5,812,0	1.08908	5,821,2	0.9375	5,875,4	0.6119	6,056,4	0.3383	6,264,8	0.24783	6,367,9	0.22650
200	11,579	0.8993	11,601	0.57123	11,620	0.4924	11,727	0.3213	12,083	0.1737	—	—	—	—
500	28,533	0.3861	28,609	0.24765	28,661	0.2143	28,934	0.1409	29,796	0.07288	—	—	—	—
700	39,712	0.2863	—	—	—	—	—	—	41,455	0.05419	—	—	—	—
1,000	56,010	0.2105	56,209	0.13479	—	—	—	—	58,526	0.0404	—	—	—	—
2,000	107,877	0.1208	108,403	0.07733	—	—	—	—	112,693	0.02384*	—	—	—	—
3,000	156,342	0.09132	157,238	0.05910	—	—	—	—	163,265	0.01810*	—	—	—	—
4,000	201,848	0.07936	203,054	0.05868	—	—	—	—	210,580	0.01519*	—	—	—	—
5,000	244,710	0.07519	—	—	246,876	0.04471	—	—	—	—	—	—	—	—
5,500	265,800	0.07391	—	—	—	—	—	—	—	—	—	—	—	—

* Conductivity data were reported in I.C.T. for 122° F.; should be 212° F.

Table 5 — Electrical Resistivity $(R_w)_t$ in Ohm-meters and Ratio $(R_w)_{32}/(R_w)_t$ of Aqueous Sodium Chloride Solutions for Various Temperatures t as a Function of Sodium Chloride Concentration as Parts per Million by Weight.

Sodium Chloride Concentration (in ppm by weight)		TEMPERATURE IN DEGREES FAHRENHEIT						
		32°	64.4°	77°	122°	212°	284°	312.8°
60	$(R_w)_t$	147.0105	91.1872	78.1909	50.1520	28.6560	21.4719	19.6554
	$(R_w)_{32}/(R_w)_t$	1.	1.61215	1.88015	2.93130	5.13018	6.84665	7.47939
100	$(R_w)_t$	88.8074	55.0804	47.2224	30.2861	17.3268	12.9807	11.8824
	$(R_w)_{32}/(R_w)_t$	1.	1.61232	1.88062	2.93228	5.12544	6.84150	7.47386
300	$(R_w)_t$	30.1407	18.7255	16.0642	10.3099	5.9028	4.4425	4.0692
	$(R_w)_{32}/(R_w)_t$	1.	1.60961	1.87627	2.92347	5.10616	6.78462	7.40703
1,000	$(R_w)_t$	9.3543	5.81792	4.9988	3.24205	1.84581	1.39497	1.2844
	$(R_w)_{32}/(R_w)_t$	1.	1.60784	1.87131	2.88530	5.06786	6.70574	7.28301
3,000	$(R_w)_t$	3.25432	2.03200	1.75034	1.14824	.65155	.49395	.45834
	$(R_w)_{32}/(R_w)_t$	1.	1.60154	1.85925	2.83418	4.99473	6.58836	7.10023
6,000	$(R_w)_t$	1.67809	1.05717	.911432	.60004	.34124	.25784	.23948
	$(R_w)_{32}/(R_w)_t$	1.	1.58734	1.84116	2.79663	4.91762	6.50826	7.00722
10,000	$(R_w)_t$	1.03366	.656130	.56632	.37273	.208558	....	....
	$(R_w)_{32}/(R_w)_t$	1.	1.57539	1.82522	2.77321	4.95622	....	....
30,000	$(R_w)_t$	.36897	.23729	.20548	.136328	.07243	....	....
	$(R_w)_{32}/(R_w)_t$	1.	1.55493	1.79565	2.70649	5.09416	....	....
100,000	$(R_w)_t$	.12881	.082789	....	....	.02577	....	....
	$(R_w)_{32}/(R_w)_t$	1.	1.55588	....	....	4.99845	....	....
200,000	$(R_w)_t$	.07975	....	....	....	.01549	....	....
	$(R_w)_{32}/(R_w)_t$	1.	....	....	....	5.14848	....	....
Avg.	$(R_w)_{32}/(R_w)_t$	1.00000	1.59078	1.85013	2.84238	5.05393	6.67350	7.24940

values for 64.4°F were obtained by linear interpolation between the 50°F and 68°F values of the tables. The values for 284°F and 312.8°F above the boiling point of water were not available in the critical tables for salt solutions and were therefore estimated by respectively multiplying the specific gravities of salt solutions at 68°F with the ratio of 0.92084 between the specific gravity of water at 284°F and at 68°F and the ratio of 0.91301 for temperatures of 312.8°F and 68°F.[5] From these data Table 3 was prepared, which shows concentration C_t in milligram mols per liter of solution at temperature t as a function of weight concentration in ppm obtained from the relationship:

$$C_t = \frac{g_t \times ppm}{58.45} \quad . \quad . \quad . \quad . \quad (4)$$

RESISTIVITY *VS* WEIGHT CONCENTRATION

In order to obtain the desired relationship between resistivity $(R_w)_t$ and weight concentration in ppm it was necessary to interpolate between the values of Table 3 to obtain the weight concentration (ppm) for the C_t values and temperatures of Tables 1 and 4. Combination of this interpolated (ppm) data with the resistivity $(R_w)_t$ data for the same C_t and t values yielded a direct relationship between $(R_w)_t$ and ppm for various temperatures t, as shown in Table 4, and depicted on the double logarithmic chart of Fig. 1.

For a series of weight concentrations of 60, 100, 300, 1,000, 3,000, 6,000, 10,000, 30,000, 100,000, and 200,000 ppm the corresponding electrical resistivities $(R_w)_t$ at temperatures of 32°, 64.4°, 77°, 212°, 284° and 312.8° were then computed by direct interpolation between the data of Table 4 and Fig. 1 under the assumption that over limited intervals the relationship between $(R_w)_t$ and ppm for a given temperature is a straight line on double log paper. That this assumption is a reasonable one to make may be noted from a close inspection of Fig. 1. This interpolation led to the data in Table 5.

In addition to the calculated resistivities, we have also shown in this table the ratio $(R_w)_{32}/(R_w)_t$ of the resistivity of a salt solution of given con-

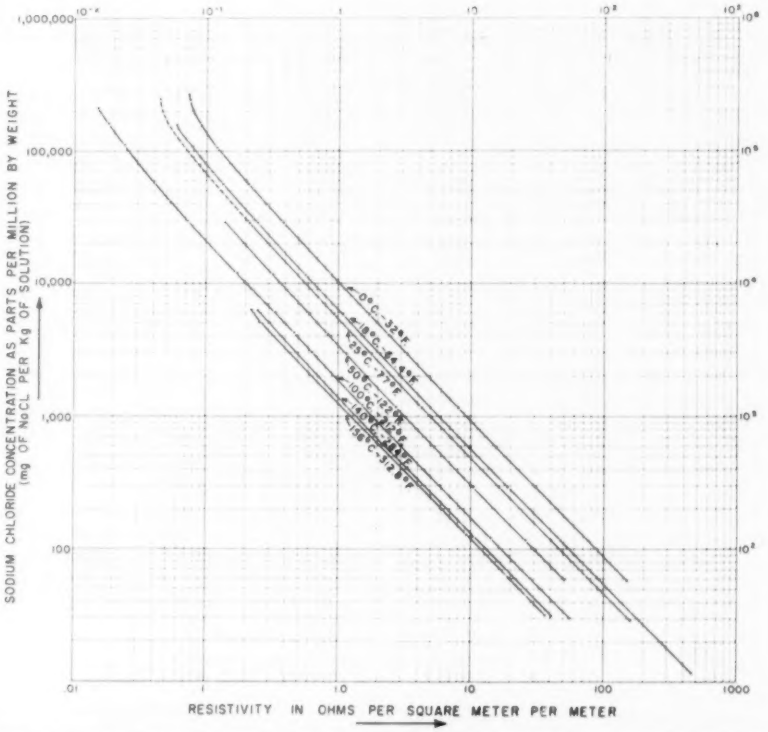


FIG. 1 — ELECTRICAL RESISTIVITY OF SODIUM CHLORIDE SOLUTIONS VS CONCENTRATION IN PPM AND TEMPERATURE.

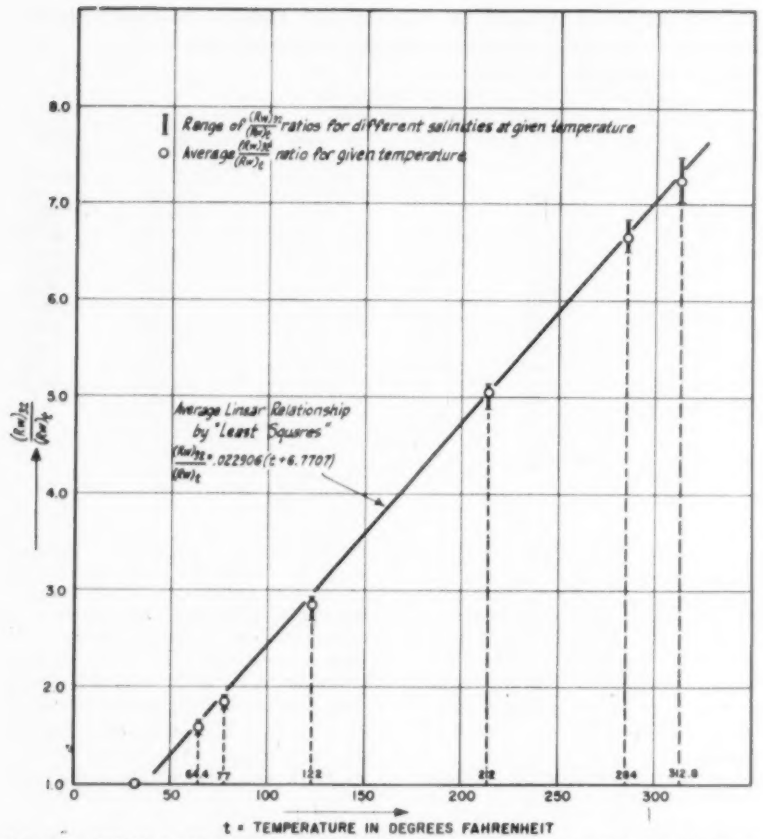


FIG. 2 — LINEAR RELATIONSHIP BETWEEN TEMPERATURE AND THE RATIO OF RESISTIVITY $(R_w)_{32}$ at 32° F AND RESISTIVITY $(R_w)_t$ AT t° F FOR SODIUM CHLORIDE SOLUTIONS.

centration at 32°F to the resistivity of this same solution at a higher temperature. It will be noted that these ratios are reasonably constant for a given temperature throughout the entire salinity range studied. The average ratios (corrected for the missing high salinity figures by the trends in $(R_w)_{32}$ and $(R_w)_{212}$ are shown at the bottom of this table.

These ratios were then plotted as ordinates on the chart of Fig. 2 against the temperature in degrees Fahrenheit as abcissa; the averages are shown as circles.

From inspection of the chart of Fig. 2 it will be observed that the ratios $(R_w)_{32}/(R_w)_t$ very nearly seem to follow a linear pattern with respect to temperature. The equation of such a straight line relationship, as determined by the "method of least squares" and as shown on Fig. 2, is:

$$\frac{(R_w)_{32}}{(R_w)_t} = .022906\ (t + 6.77) \quad . \quad . \quad (5)$$

As a first approximation for the temperature correction factor this relationship will be quite satisfactory, although for subsurface temperatures below 150° F the calculated ratios will be slightly above the true values. In order to convert the electrical resistivity of a salt solution which is measured under surface conditions at a temperature t_1°F to the resistivity of the same salt solution at a bore hole temperature of t_2°F this simplified or first approximation relationship reduces to:

$$(R_w)_{t_2} = (R_w)_{t_1} \times \frac{t_1 + 6.77}{t_2 + 6.77} \simeq (R_w)_{t_1} \times \frac{t_1 + 7}{t_2 + 7} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (6)$$

For a quick resistivity correction this is a simple and handy formula. Its usefulness may be illustrated with the following example:

Resistivity mud filtrate measured at the surface at a temperature of 64.4°F is .656 ohm-meters $(R_w)_{77}$. What is the resistivity of this same mud filtrate under bottom hole conditions at 122°F.

With Equation 6:

$$(R_w)_{122} = .656 \times \frac{64.4 + 7}{122 + 7} =$$

.363 ohm-meters.

From inspection of Table 5, from which this example was taken, it may be noted that the true resistivity at 122°F (10,000 ppm) is .373 ohm-meters.

NOMENCLATURE

SP = static self potential in millivolts

K = constant in SP relationship (ranges from 50 to 110 with 70 as a good average value)

R_{mf} = electrical resistivity of mud filtrate in ohm-meters

R_w = electrical resistivity of interstitial or connate water in ohm-meters

$\log_{10}$ = logarithm to the base 10

$\bigwedge$ = electrical conductivity, expressed as 10^5 times the specific conductivity in ohm^{-1}cm^{-1} per unit of concentration in milligram mols per liter of solution

k = specific conductivity in ohm^{-1}cm^{-1}

C_t = concentration in milligram mols per liter of solution at a temperature t

t = temperature in degrees Fahrenheit

$(R_w)_t$ = electrical resistivity of salt solution at temperature t in ohm-meters

$(R_w)_{32}$ = electrical resistivity of salt solution at 32° Fahrenheit in ohm-meters

g_t = specific gravity or density in grams per cubic centimeter

ppm = parts per million sodium chloride by weight

58.45 = molecular weight of NaCl

REFERENCES

1. Mounce, W. D., and Rust, W. M., "Natural Potentials in Well Logging," *Trans.* AIME (Geophysics), (1945) **164**, 288.
2. Doll, H. G., "The S.P. Log: Theoretical Analysis and Principles of Interpretation," *Trans.* AIME, (1949) **179**, 146.
3. Wyllie, M. R. J., "A Quantitative Analysis of the Electrochemical Component of the SP Curve," *Trans.* AIME (1949) **186**, 17.
4. *International Critical Tables of Numerical Data, Physics, Chem. and Techn.*, (1929) **IV**, 233.
5. *International Critical Tables of Numerical Data, Physics, Chem. and Techn.*, (1928) **III**, 79.
6. *Handbook of Chemistry and Physics*, 32nd ed., 1,789.

★ ★ ★

Use of Volumetric Methods in Reserve Estimation

Reported by T. J. Nowak

Pacific Technology Forum

Francis J. Barker, petroleum engineer for Union Oil Co., presented the second talk in the series on "Reserve Estimation and Property Evalution" to engineers of the Los Angeles area under the auspices of the Petroleum Technology Forum. In his talk, Barker discussed the use of the volumetric method in the estimation of recoverable oil reserves. Before considering the volumetric method in detail, he presented a resume of the three methods used in obtaining reserves, namely, production decline curves, the volumetric analysis, and the material balance.

The production decline curve method was discussed at the first meeting in the series and reported in the JOURNAL OF PETROLEUM TECHNOLOGY (Aug., 1953); the volumetric method as presented by Barker is reported herein; and the material balance method will be the subject of the forthcoming meeting. Barker then discussed the factors governing the choice of method to apply to a given reservoir. These factors are: purpose of estimate, size of property being evaluated, type of reservoir drive, geological conditions, location of property relative to the geological conditions, production history, and the availability of data. Barker emphasized the point that in many cases more time should be spent in scrutinizing the factors to decide on the method to use rather than in the application of a method. Using the method most applicable to a given property, Barker pointed out that the accuracy of recoverable reserve estimation for most California fields is within a range of plus or minus 15 to 20 per cent.

The volumetric method of estimating recoverable reserves is commonly used and has been described in the literature.[1,2] It consists of calculating the amount of oil in the reservoir from the estimate of the tank oil in place per unit volume, the determination of the volume and estimating the recoverable percentage. It is essentially a study of the pore space in the oil bearing strata, the proportion of the pore space which is now occupied by oil, the relationship between the tank oil barrel and the reservoir oil barrel, and the proportion of that oil commercially recoverable. It can be applied to the entire reservoir or to a portion of a reservoir defined by definite limits such as lease boundaries. During the course of his talk, Barker discussed (1) the factors in volumetric analysis of reserves, and (2) the application of the volumetric analysis to various types of reservoirs.

Factors in Volumetric Analysis

The factors in volumetric analysis can best be considered in reference to the basic equation in which they occur. This equation gives the solution to the quantity of recoverable oil and for a gas-free reservoir it is expressed as:

$$N_R = \frac{7758Ah\phi(1\text{-}Siw)R}{F.V.F.}$$

where:

N_R = recoverable oil reserves in stock tank oil barrels.
7758 = number of barrels per acre -ft of volume.
A = area in acres of productive sand.
h = average net thickness of the oil-producing strata in feet.
ϕ = average effective porosity expressed as a fraction of the formation volume.
Siw = interstitial water saturation, fraction of pore space.
R = recovery factor, expressed as a fraction of the oil in place that is recoverable.

Cursory examination of the equation indicates that the volumetric method is basically not complicated in principle or in mathematics. Although this is true, a thorough examination of the factors that enter into the equation indicates that considerable judgment and experience are required on the part of the appraiser in its application. Thus, the problem of calculating average values for the factors in the equation is complicated by the heterogeneity of the reservoir rock and by the irregularities in both shape and thickness of the reservoir. For this reason, accuracy in volumetric estimates of oil reserves is dependent both on the completeness and accuracy of the data and on the ability of the appraiser to visualize and analyze the data in terms of average values that are applicable to the reservoir conditions. This will be borne out below in the discussion of the factors which are in the equation.

Sand thickness for most California reservoirs is difficult to evaluate because of the heterogeneity of the reservoir rock. Generally only that portion of the producing interval which contains oil saturation above an arbitrary fixed value and has an air permeability above 10 md is considered in obtaining net sand thickness of the pay strata. It can readily be calculated from core analyses providing good core recovery is obtained. It can also be calculated from electric logs, particularly from the self-potential curves of the logs and from the MicroLog. The accuracy with which the net sand thickness is determined depends on the variations of sand and shale sections. For California sands it is usually within 20 per cent and may be within 2 to 3 per cent.

Normally the area and the average sand thickness are expressed together as the bulk volume of the reservoir. It is usually computed from an isopachous map. Various techniques are used in obtaining volumes of the properties or of the entire reservoir from the isopachous map. For parcels of land, the prism, layer or concentric circle techniques are used. Normally the technique involves planimetering of the area between isopachs in conjunction with the use of graphical integration methods or by using either the trapezoidal rule or Simpson's rule.[3]

Porosity is defined as the percentage by volume of pore spaces within the reservoir sample. It can be measured in the laboartory by either the water saturation, the porosimeter, or the sand grain density method. The first two methods give the effective porosity, in which the pore spaces are interconnected, whereas the third method gives the total porosity, which includes both the isolated and the interconected pore spaces. It can also be calculated from the electric log data, especially from MicroLog data. Generally, any core analysis method gives results well within limits of other discrepancies in the volumetric formula. For use in the above equation, the

porosity data are analyzed either arithmetically or on an areal basis to obtain an average porosity value for the reservoir. For California sands the normal range of porosities is usually between 14 and 35 per cent with majority of the values falling in the 19 to 27 per cent range.

Interstitial water is the water remaining in the reservoir after the accumulation of oil and gas in the interstices of the reservoir. Some of the common methods of obtaining the values for interstitial water are: capillary, dynamic, oil base cores, and curves from similar fields based on permeability *vs* interstitial water. The less common methods in use are mercury injection, centrifuge and evaporation. When the interstitial water is determined in the laboratory on cores it is generally thought to be that water which satisfies the capillary irreducible minimum of the core. Often significant variations exist in the values for the interstitial water obtained by the different methods and discretion in choice of method is essential. For a given reservoir, the average interstitial water value is obtained by arithmetically averaging the data or preferably by treating the data statistically and using the permeability *vs* interstitial water curve on semi-log paper and averaging groupings. For most California sands the interstitial water values range from 5 to 40 per cent with the majority falling in the 20 to 30 per cent range.

Formation volume factor is defined as the volume in barrels at reservoir temperature and pressure occupied by 1 bbl of stock tank oil and associated gas which will go into solution at the reservoir conditions. It is determined in the laboratory for either or both processes of gas liberation: namely, the differential and the flash processes. The actual value is somewhere between the values obtained by the two processes. In the absence of laboratory data, Standing's correlation can be used provided that the trapping conditions used, the gas-oil ratio, and the gas and oil gravities are known as well as the reservoir temperature and pressure. For California black oil wells, the formation volume factor will vary in the range from 1.0+ to 1.7.

Recovery factor is the proportion of the estimated reservoir oil that can profitably be produced. The care exercised in determining the recovery factor will depend upon the purpose of the recoverable reserve estimation. If the purpose of the estimate is for purchasing property, an accurate determination of the recovery factor is important; if the estimate is for distribution of equities in the field, an accurate determination of the recovery factor is unimportant. In choosing a recovery factor, it is necessary to consider both physical and economic effects. The sources from which the recovery factors can be estimated are:

1. Other fields that have been depleted and that produce from the same sands and depth.
2. Laboratory tests.
3. Mobility ratio curves.
4. Knowledge of type of drive.
   a. Depletion, 15-28 per cent recovery.
   b. Water drive, 25-40 per cent recovery.
   c. Gravity drainage, 30-50 per cent recovery.

For California reservoirs the recovery of 250 bbl per acre-foot is considered a fair average, with the usual range of 100 to 450 bbl per acre-foot.

Application of Volumetric Analysis

The basic concept underlying the applicatioin of the volumetric method to a given property is that oil will be produced from the property in relation to the relative amount of oil it has in place. Except in special cases, no movement of oil is assumed across property lines. An example of a special case where it is applicable regardless of the presence of drainage across property lines is in unit plan areas where the operator's correlative rights as to the oil in place are assured. It is not applicable to most small properties in water drive type or in gravity drainage type fields. Several illustrations of the application of the volumetric method of analysis are presented to the following actual reservoir problems:

1. As an exploration check on any anticipated new production. For example, the estimated recovery is:
(200 bbl/acre-ft) (20 ft) (10 acre/well) = 40,000 bbl/well
The estimated value of oil per well exclusive of the drilling cost is:

$$40{,}000 \text{ bbl} \times \$1.48 \text{ per bbl} = \$59{,}200$$

The cost of a well to 8,000 ft is $90,000. Therefore, even a successful well on the basis of the 10-acre spacing would result in a loss of $30,800.

2. As a check on validity of other apparently more appropriate methods of recoverable reserve estimation. For example, six wells had produced 160,000 bbl or 200 bbl/acre-ft based on total of 800 acre-ft on property. The average well production is eight B/D and the economic limit per well is 3 B/D. The production data trend indicates a 5 per cent decline. Reserves based on 5 per cent decline are:

$$\frac{6 \text{ wells } (8 \text{ B/D/well} - 3 \text{ B/D/well}) \ 365}{0.05} = 219{,}000 \text{ bbl}$$

$$\frac{219{,}000 \text{ bbls}}{800 \text{ acre-ft}} = 274 \text{ bbl/acre-ft}$$

therefore, the ultimate recovery is

$$200 \text{ bbl/acre-ft} + 274 \text{ bbl/acre-ft} = 474 \text{ bbl/acre-ft}$$

Inasmuch as the 474 bbl/acre-ft ultimate recovery for a California depletion type of pool is probably too high, a more detailed study is necessary to verify validity of the decline method. Subsequently it was found that an active water drive was present in the field and the high value for the ultimate recovery was shown to be incorrect.

3. As a method for determining the recovery factor. For example, consider a field under a water drive containing 1590 bbl/acre-ft of oil. The oil sand volume is 2,325 acre-ft. While the water flooded out 1,342 acre-ft the well produced 700,000 bbl of oil. The recovery factor for these conditions is:

$$\frac{700{,}000 \text{ bbl}}{(1{,}590 \text{ bbl/acre-ft}) \quad (1.342 \text{ acre-ft})} = 32.8\%$$

The correct reserves are:
(2,325 acre-ft − 1,342 acre-ft) (1,590 bbl/acre-ft) (.328) = 512,600 bbl
Usually the estimates of this type are somewhat conservative.

4. Application to portions of a depletion type field. It can be applied to all properties in most portions of a depletion type field providing the following basic assumptions hold: namely, (1) no formation of single gas cap at peak of structure, (2) all wells are on same spacing pattern, and (3) the wells are produced in relation to sand thickness.

5. Application to any field which is to be taken as a whole and is still in the semi-flush stage. It can be applied to the entire field that is still in the semi-flush stage of depletion providing (1) the field is under one ownership, or (2) the field is operated as a unit in which all interests are pooled.

REFERENCES

1. Dodge, J. F., Pyle, H. C., Trostel, E. G.: "Estimation by Volumetric Methods of Recoverable Oil and Gas from Sands," *Bull.* AAPG. (1941) 25, 1302.
2. Paine, Paul: "Oil Property Valuation," John Wiley and Sons, Inc., New York. (1949).
3. Pirson, S. J.: "Elements of Oil Reservoir Engineering," McGraw-Hill Book Co., Inc., New York. (1950).
4. Standing M. B.: "A Pressure-Volume-Temperature Correlation for Mixtures of California Oils and Gases," A.P.I. *Drilling and Production Practice* (1947) 275.

What's NEW

In Perforating, Logging, and Fishing Tool Services

McCULLOUGH
NEW SERVICES • NEW TOOLS
NEW WAYS OF DOING THINGS

Latest News About New Tools, Techniques and Services

More Oil Flows...

13 B/D to 158 B/D

Well previously perforated by other make bullets and jets without increasing production. After 32 holes shot by improved McCullough Standard Glass Jet, production increased to 158 B/D. Casing: 7", 20 lb. cemented. Depth: 3400 feet.

Through Cleaner, Deeper Holes...

Peak Production of 60 B/D had dropped to 20 B/D over a period of years. Well perforated with 1314 improved McCullough M-3 Burrless Bullets, between 6234 and 6544 feet. Casing: 7", 26 lb. cemented.

20 B/D to 100 B/D

Made by Improved McCULLOUGH Perforators...

0 B/D to 360 B/D

Offset well. 360 B/D through four ½" test holes between 5203 and 5204 feet, shot with improved McCullough M-3 Burrless Bullets through 5½", 15½ lb. cemented casing. Well completed with 38 Super Glass Jets and 38 M-3 Burrless Bullets for production of 408 B/D, without acidizing. Neighboring wells had to be acidized to produce.

Now 25% Deeper Penetrating!

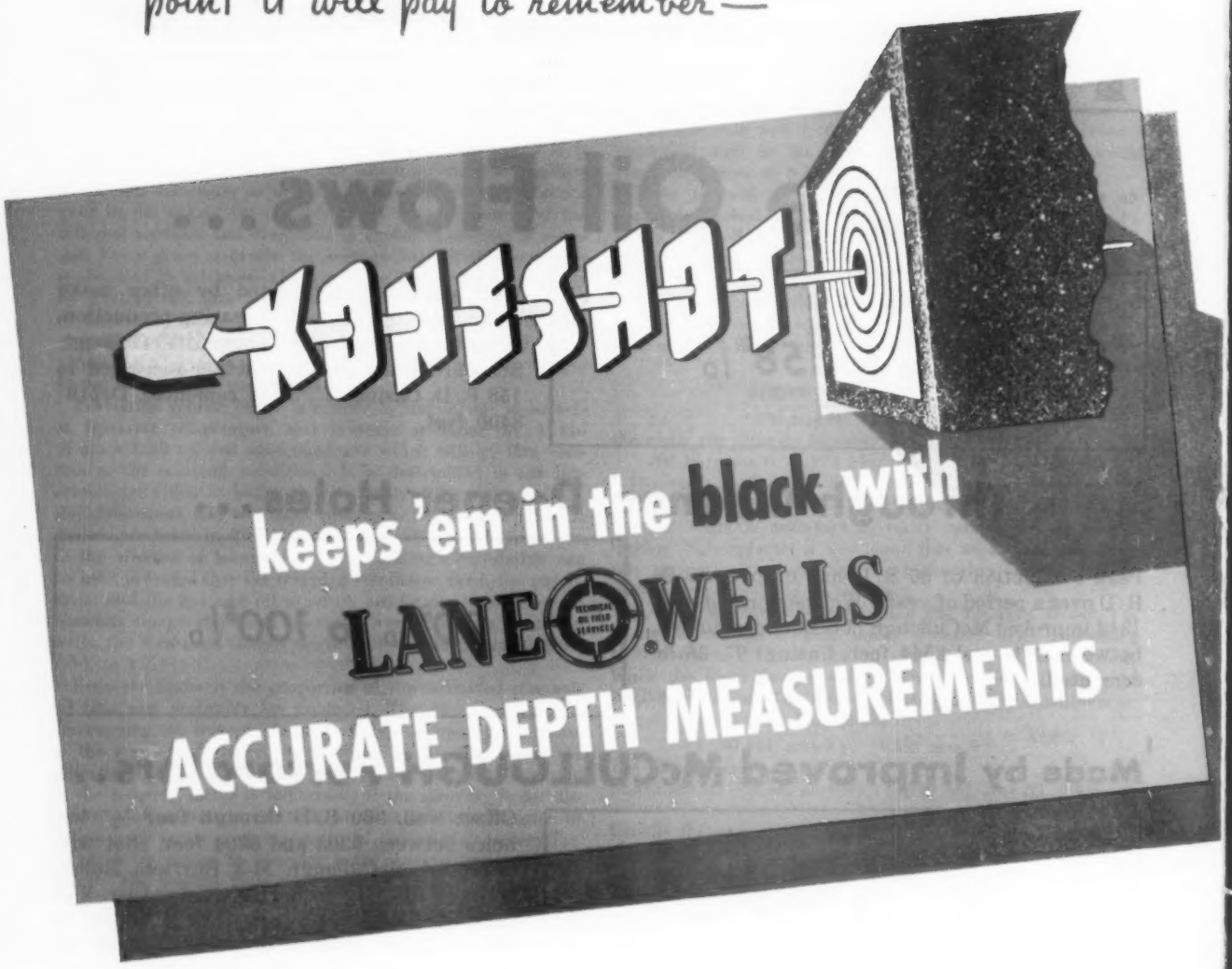
If you don't have a copy of "How To Get More Oil," write for yours today, or ask your McCullough Service Engineer. Thirty-two pages of usable perforating data to help you "Get More Oil."

PERFORATING, RADIATION LOGGING, AND FISHING TOOL SERVICE—ANYWHERE—ANYTIME.

McCULLOUGH TOOL COMPANY
5820 South Alameda Street, Los Angeles 58, California
405 McCarty Street (P. O. Box 2575) • Houston, Texas
CABLE ADDRESS: MACTOOL
EXPORT OFFICE: Los Angeles, California
CANADA: Edmonton, Calgary, Grande Prairie, Alb.; Regina, Saskatchewan
VENEZUELA: United Oilwell Service Co., S.A.; Caracas, Anaco, Maracaibo

SERVICE LOCATIONS: TEXAS: Houston, Snyder, Alice, Cisco, Corpus Christi, McAllen, Odessa, Tyler, San Angelo, Victoria, Wichita Falls, Luling, Beaumont, Sherman, Midkiff, El Campo. **OKLAHOMA:** Oklahoma City, Guymon, Healdton, Hominy, Wewoka. **ARKANSAS:** Magnolia. **MISSISSIPPI:** Laurel. **NEW MEXICO:** Hobbs. **KANSAS:** Great Bend. **WYOMING:** Casper. **CALIFORNIA:** Los Angeles, Avenal, Bakersfield, Ventura. **LOUISIANA:** Houma, Lake Charles, New Iberia, Shreveport. **COLORADO:** Sterling. **NORTH DAKOTA:** Williston. **UTAH:** Vernal.

When you plan for
shaped-charge perforating here's a
point it will pay to remember—



P.S. Thoroughly-experienced
crews give you fast, safe service
from Lane-Wells 69 branches.

Tomorrow's Tools - Today!®

LANE-WELLS General Offices, Export Office, Plant · 5610 So. Soto St., Los Angeles 58

LOS ANGELES • HOUSTON • OKLAHOMA CITY • LANE-WELLS CANADIAN CO. IN CANADA • PETRO-TECH SERVICE CO. IN VENEZUELA

AK-605

Government Report Surveys Employment, Education and Income of Engineers

Now available on request to the Bureau of Labor Statistics, Washington 25, D. C., is a 48-page mimeographed report on *Employment, Education, and Income of Engineers, 1949-50 — A Survey of Engineering Society Members of Full Professional Grade.* The survey was made by Engineers Joint Council on behalf of the Department of Defense. It covers returns from 55,000 engineers who hold full professional grades of membership in national engineering societies, or more than half of society members of full professional grade. Of the returns, about 40 per cent came from mechanical engineers, 25 per cent from civils, 15 per cent from electricals, 12 per cent mining and metallurgical, and 7 per cent chemical. The groups with the lowest median age, 42 years, were the chemical and mining and metallurgical engineers. For the mechanicals the median was 43 years, for the electricals 46, and for the civils 47. There were only 56 women in the 55,000 considered in the survey.

Of the total in all fields, 3.7 per cent held doctors' degrees (4.3 for mining and metallurgical engineers); 16.4 per cent held masters' degrees (16.5 for mining and metallurgical); 59.5 per cent held bachelors' degrees 61.9 mining and metallurgical); and 20.3 per cent held no degree (17.3 for mining and metallurgical).

Median incomes of those reporting ranged as follows:

Self employed, employer, or owner of business, $14,700; self-employed, independent consultant, $10,700; private industry, $8,400; educational institutions, $7,100; government, $6,600.

Among mining and metallurgical engineers, 81.7 per cent were in private industry; 6.2 per cent worked for governmental agencies; 5.2 per cent were educators; 3.7 per cent were independent consultants; 1.8 per cent were employers or owners; and 1.3 per cent worked for foundations.

Median incomes of various kinds of engineers, 35 years of age and over, 44,000 engineers reporting: chemical, $9,000; mechanical, $8,400; mining, metallurgical, electrical, $8,000; civil, $7,100.

Median annual income of mining and metallurgical engineers, by age groups and highest degree earned are listed in the complete report. ★ ★ ★

Pittsburgh Petroleum Group Plans Meeting for Nov. 6

The Petroleum Group of the Pittsburgh Section of AIME has announced the program for its eighth annual Off-the-Record Meeting to be held Nov. 6. James H. Henderson, Gulf Research and Development Co., is program chairman.

Papers to be presented at the morning session are "Underground Storage of Gas in Bottle Type Holders," by A. B. Wilder and S. C. Hibbard, U. S. Steel Corp.; "Fracturing of Oil and Gas Sand Formations,' by Don Hurst, Dowell, Inc.; and "Applications of Gamma Ray and Neutron Logging," by C. W. Tittle, Gulf Research and Development Co.

The afternoon session will consist of "The Recovery of Gas by Water Displacement from an Unconsolidated Sand," by Paul Root, John Calhoun, and L. T. Bissey, The Pennsylvania State College; "Oil Recovery by In Situ Combustion," by Carl S. Kuhn, Magnolia Petroleum Co.; and "Cathodic Interference on Underground Structures," by A. B. Lauderbaugh, Manufacturers Light and Heat Co.

Sessions will be held in the William Penn Hotel in Pittsburgh. Other AIME divisions active in the Pittsburgh area will hold separate technical sessions during the meeting. A luncheon and a banquet will be sponsored by the combined groups. ★ ★ ★

AIME Officer Candidates To Be Declared Elected

No opposing candidates for nominations for AIME officers in 1954 had been received on Sept. 1, so the ticket will be formally declared elected at the November meeting of the Board of Directors, as provided in the AIME by-laws. The ticket is as follows: President-elect, H. DeWitt Smith, vice-presidents, T. B. Counselman and Harold Decker; directors, the above with E. C. Babson, George D. Dub, Ralph E. Kirk, Carleton C. Long, Earl R. Marble, and Philip J. Shenon. All of these men will serve three-year terms as director beginning next February. Another director will be elected by the incoming board at the February meeting, for a one-year term, to fill the unexpired term as director of T. B. Counselman.

EMC Advises Engineers Facing Military Service

Engineering Manpower Commission has prepared the following statement which should be of interest to young men recently, or about to be, inducted into military service, or their parents.

U. S. Army Scientific and Professional Personnel Program

The U. S. Army Scientific and Professional Personnel Program should be of special interest to recent engineering graduates who will shortly be inducted into the armed forces. It was designed to channel as many such persons as possible into army billets which will ensure the maximum utilization of their engineering or scientific training and experience. This should promote their own continued professional development and the advancement of the army's technical programs. The program is described in detail in Department of the Army Special Regulation No. 615-25-11, dated August 7, 1952.

The regulation provide for the identification, classification, assignment, and utilization of those persons who are qualified to perform scientific and professional level duties in research and development, instruction, and related work of professional or scientific nature.

Commanders of reception centers and other installations conducting initial reception processing are responsible for the proper identification and indoctrination of scientific and professional personnel and for their transfer to appropriate basic training.

The regulations concerning the selection of scientific and professional personnel are far too complex for adequate reproduction here. The regulations differ for each major scientific and professional field. In some cases, only a BS degree is required. In others, a bachelor's degree plus a certain amount of experience or an advanced degree is required.

Personnel qualified as scientific and professional personnel are assigned a military occupational specialty number MOS) which reflects their specialty and is intended to be used as a guide in their assignment to billets in which their training and experience will be utilized. All the major engineering and scientific fields are covered by the regulation although, as has been said previously, the qualifications differ somewhat.

Copies of the basic regulation are available from the Department of the Army, Washington 25, D. C. ★ ★ ★

Personals

HARRY P. STOLZ was this summer promoted from the rank of captain in the U. S. Naval Reserve to that of rear admiral. This was one of two appointments made by the President to two-star rank in his home state of California, and one of eleven selections in the Naval Reserve throughout the nation.

Stolz has served for more than 30 years in the armed forces reserve. He served in the Army during the first World War, and in World War II in the Navy, on active duty before the start of the war from June, 1941, to August, 1946. He was instrumental in activating and administering Naval Petroleum Reserve No. 1 at Elk Hills, Calif., commencing in 1938 as a member of a Naval Petroleum Reserves Advisory Board, was in command for the Navy during the period of World War II development, and upon return to civilian status has continued his affiliation in a consulting capacity as a Navy member of the engineering committee. Stolz has been a petroleum consultant for the past 22 years and is a partner in the firm of Stanley, Stolz and Dodson, consulting engineers and geologists, in Los Angeles.

+

ROBERT L. HOSS is the new division engineer in Midwest Oil Corp.'s Denver, Colo. offices. He formerly was associated with the Humble Oil & Refining Co. as senior petroleum engineer.

+

C. R. DODSON has resigned as professor and head of the petroleum engineering department at the University of Southern California. He plans to spend full time on consulting work in the office of Stanley, Stolz and Dodson, Los Angeles firm of consulting petroleum engineers and geologists. He has been a partner in the firm since July, 1951. Dodson was with the Standard Oil Co. of California from 1936 to 1947, when he became associated with USC. He has been active in AIME and API work and is a charter member of the Petroleum Club of Los Angeles.

+

MIKE O. SMITH, JR., petroleum engineer with Cardinal Chemical Co. at Odessa, Tex., was transferred to the company's Hobbs, New Mex. office on August 1.

+

CHARLES W. WELBY has assumed his new duties as a development geologist in the California Co.'s New Orleans offices. Prior to his transfer to his present position he served as a geologist in the company's West Jackson, Miss., exploration department.

+

HAROLD VANCE was recently elected a vice-president of the Second National Bank of Houston. He will remain manager of the bank's oil and gas division, a posiiton which he has held for the past year. Vance was previously head of the petroleum engineering department of Texas A & M College. Born in Geneva, Ind., he is a graduate of the University of California and is a prolific writer of technical papers. He is a member of the API and the Texas Independent Producers and Royalty Owners. Vance has also been active in AIME affairs, and is a former secretary-treasurer of the Petroleum Branch.

+

PAUL N. WEIDNER, former chief reservoir engineer with Creole Petroleum Corp. in Caracas, Venezuela, has been transferred to the company's office at Carpito, Estado Monagas, Venezuela.

+

GEORGE L. DUGGAN has moved from Sundown, Tex., to Andrews, Tex., where he is employed as a field engineer with the Texas Co.

+

REX E. CHEEK, who has been awarded a master's degree in petroleum engineering at the University of Oklahoma, has joined Ball Associates, oil and gas consultants in Washington, D. C., and will make his home in Arlington, Va.

FRANK G. MILLER has been appointed head of the department of petroleum engineering at Stanford University, to succeed Richard V. Hughes, who recently accepted a position in industry. Miller comes to Stanford from the U. S. Bureau of Mines where he has been engaged as assistant supervising engineer, petroleum and natural-gas branch, Region III, San Francisco, Calif. He has specialized for many years in studies of fluid behavior in porous media, and in the fundamentals of oil-reservoir engineering. He has authored a number of technical papers, including a Bureau of Mines bulletin, now in press, relating to multiphase flow theory and well spacing. His BS degree was awarded in 1933 by the University of California, in petroleum engineering, and his MS and PhD degrees were awarded in 1939 and 1950, respectively, by the same institution, in mechanical engineering, with reasearch relating to petroleum production.

+

M. S. WISE, JR., formerly of Caracas, Venezuela, has returned to the U. S. and is now with the Colombian Petroleum Co. in New York.

Technical Conference Set At State College, Pa.

The 17th Technical Conference on Petroleum Production will be held at State College, Pa., Oct. 28-30, under the joint sponsorship of The Pennsylvania State College and the Pennsylvania Grade Crude Oil Association. Technical sessions will be held in the Mineral Industries Building on the campus.

The program will include four technical sessions and an inspection of the laboratories of the division of petroleum and natural gas and the division of geophysics and geochemistry. Staff members will be on hand to describe current research projects.

Registration fee, including a banquet on Oct. 29 and preprints, is $10. Tickets for a football game Oct. 31 between Penn State and West Virginia will be available at the registration desk. ★ ★ ★

Proposed for Membership, Petroleum Branch

Total AIME membership on June 30, 1953, was 19,010; in addition 1,543 Student Associates were enrolled.

PETROLEUM BRANCH ADMISSIONS COMMITTEE

J. H. Sullivan, Chairman; Thomas S. Bacon Vice-Chairman; A. E. Caraway, Frank C. Kelton Thomas E. Morton, and F. C. Prutzman.

INSTITUTE ADMISSIONS COMMITTEE

O. B. J. Fraser, Chairman; Philip D. Wilson, Vice-Chairman; F. A. Ayer, A. C. Brinker, R. H. Dickson, Max Gensamer, Ivan A. Given, Fred W. Hanson, T. D. Jones, G. W. Lutjen, E. A. Prentis, Sidney Rolle, J. T. Sherman, F. T. Sisco, and R. L. Ziegfeld.

The Institute desires to extend its privileges to every person to whom it can be of service, but does not desire as members persons who are unqualified. Institute members are urged to review this list as soon as possible and immediately to inform the Secretary's office if names of people are found who are known to be unqualified for AIME membership.

In the following list C/S means change of status; R, reinstatement; M, Member; J, Junior Member; A, Associate Member; S, Student Associate.

ARKANSAS

El Dorado — Scull, mayd, William Clark (R, C/S, S-J).

CALIFORNIA

Burlingame — Adams, Elmo Walter (R, M).
Los Angeles — Jappay, David Walter (R, C/S, S-J).
Manhattan Beach — Culligan, Paul Thomas (J).
Reseda — Baseeberg, Cecil Oliver (J).

COLORADO

Denver — Cusator, James Alan (M).

ILLINOIS

Mattoon — Bottler, Joseph Sebastian, Jr. (M).

KANSAS

Eureka — Crawford, William Joseph (M).
Wichita — Aitken, Robert Ramsay (J); Stewart, James Milo (J).

LOUISIANA

Shreveport — Graham, Robert Wayne (J); McDonough, James Drew (M).

NEW MEXICO

Monument — Kidd, Harold Chester (J).

NEW YORK

New York — Gillespie, Darl D. (R, C/S, J-M).

OHIO

Granville — Vockel, Richard Landis (M).

OKLAHOMA

Duncan — Bradley, Billie Jack (R, C/S, S-J); Gras, Ernst Herman (M); Hower, Wayne F. (M); Manson, Charles D., Jr. (M); Rawlings, Herbert Earl, Jr. (M); Waters, Almon Browing (M).
Oklahoma City — Butler, Roy (J); Wilshusen, Richard Clanton (J).
Tulsa — Jacoby, Robert Harold (J); Keeling, Lee Aaron (M); LaRue, John William (R, J); Martin, Robert George, Jr. (A); Nagy, Bartholomew Stephen (J).

PENNSYLVANIA

Harmarville — Jakes, Harry Robert (R,C/S, S-J).

TEXAS

Abilene — Feagan, Richard Wynne (C/S, A-M).
Austin — Cornell, David (J).
Burkburnett — Durr, W. L. (J).
Dallas — Graham, Joe Edwin (R, M); Harris, Virgil Byron, (R, C/S, S-M); Schaefer, Woodrow Wilson (A); Schwab, Carl Milton (M); Ward, Kenneth Watts (M).
Fort Worth — Candler, Arthur Van Buren, Jr. (R, C/S, S-M); Carter, Frank Stephen (M); Gaines, Claude Dewey, Jr. (J).
Houston — Broughton, John Willis (J); Bugbee, James McKean, Jr. (M); Lundy, Phillip Don (J); Morgan, Thomas Harrington (A); Perry, Douglas (A); Rickard, James Alexander (J).
Longview — Goble, James Henry (J).
Midland — Brown, Donald Ceylon (M).
Pearland — Brown, James Thomas (J).
Sinton — Crawford, David Moore (J).
Wichita Falls — Kerr, Armour James (J).

VENEZUELA

Barcelona — Loeb Van Maerssen, Otto (C/S, A-M).

OTIS TYPE S LANDING ASSEMBLIES
("Selective")

The best method of providing for 1, 2, 3, or as many as 5 Otis Sub-Surface Controls in the same tubing string

OTIS

OTIS/Otis Pressure Control, Inc.

BRANCH OFFICES THROUGHOUT THE OIL COUNTRY

PROFESSIONAL SERVICES

This space available only to AIME members.

AMSTUTZ AND YATES, INC.
Petroleum Engineers and Geologists
Estimates of Oil and Gas Reserves
Property Valuations, Reservoir Analyses
Geologic Investigations
406 KFH BLDG., WICHITA 2, KANS.

E. A. WAHLSTROM BURTON ATKINSON
PETROLEUM CONSULTANTS
Engineering - Geology
MIDLAND, TEXAS
130 Central Building Phone 4-8037

ROBERT M. BEATTY
Consulting Geologist
Esperson Building Houston 2, Texas

BERGER AND PISHNY
Consulting Geologists and Engineers
901 Commercial Standard Bldg.
Fort Worth 2, Texas
Walter R. Berger Chas. H. Pishny

W. RUSSELL BIRDWELL
Consulting Petroleum Engineer
PHONE 6-6601 BOX 1348
Frontier Oil & Gas Bldg.
McALLEN, TEXAS

BRADLEY, OLIVER AND ASSOCIATES
PETROLEUM CONSULTANTS
Geology, Engineering and Management

Robert J. Bradley	R. Wayne Russell
Mac D. Oliver	H. Eugene Wright
Virgil B. Harris	Bernard J. Esunas
Otis T. Griffin	Walter A. Tynes
W. Ray Staples	Kenneth C. English

903 Employers Insurance Building
Dallas, Texas RAndolph-2241

JOHN G. CAMPBELL
Analytical and Petroleum Chemists
Podbielniak and Charcoal Analyses
Waters - Oil Field Brines
Field Sampling
PHONE: 4-3071 CORPUS CHRISTI, TEXAS

CHEMICAL & GEOLOGICAL LABORATORIES
Consultants - Investigations - Evaluations
James G. Crawford.....Chemical Engineer
H. E. Summerford.....Petroleum Geologist
F. Raymond Wheeler....Petroleum Engineer
P. O. BOX 279 CASPER, WYOMING

CRUTCHFIELD AND PRUETT
CONSULTING PETROLEUM ENGINEERS
Wilson Tower
CORPUS CHRISTI, TEXAS
John W. Crutchfield *Horton T. Pruett*

DENTON-SPENCER COMPANY, LTD.
PETROLEUM ENGINEERS AND GEOLOGISTS
PHOTOGEOLOGISTS PHOTOGRAMMETRISTS
Barron Building Calgary, Alberta

EARLOUGHER ENGINEERING
Petroleum Consultants - Core Analyses
Specializing in Secondary Recovery
Investigations - Appraisals - Operations
3316 East 21st St.
TULSA 5, OKLAHOMA
Phone: 9-6345

EASTON & SACRE
Consulting Petroleum Engineers
1660 Oak Street
BAKERSFIELD, CALIFORNIA
Phone 2-3934

FITTING & JONES
Engineering and Geological Consultants
Ralph U. Fitting, Jr.
J. R. Jones
T. W. Hassell
Petroleum *Natural Gas*
233 S. Big Spring St. Box 1637
Phone 4-4451 Midland, Texas

ROBERT D. FITTING
Petroleum Consultant
Engineering and Geology
MIDLAND, TEXAS
202 West Building Phone: 4-4922

MICHEL T. HALBOUTY
CONSULTING GEOLOGIST
AND PETROLEUM ENGINEER
Shell Building
Houston 2, Texas Phone PR-6376

R. G. HAMILTON
Electric Log Analyses
Log Analysis Conferences
Distributor Arps-Hamilton Loganalyzer
HAMILTON WELL LOG CONSULTANTS
Wright Bldg. Ph. 3-7055; 7-1825 Tulsa

JAMES A. LEWIS ENGINEERING, INC.
Petroleum Reservoir Analysts
Dallas, Texas Evansville, Indiana
Robinson, Illinois
Owensboro, Kentucky Winchester, Kentucky

B. ORCHARD LISLE
Petroleum Technologist — Research Analyst
SPECIALIZING IN MIDDLE EAST OIL
260 Majestic Bldg. FOrtune 0165
FORT WORTH 2, TEXAS

MARTIN, WILLIAMS & JUDSON
PETROLEUM CONSULTANTS
Engineering - Geology - Management
131 Central Bldg. Phone 2-5216
MIDLAND, TEXAS
William H. Martin R. Ken Williams
Edward H. Judson

WAYNE L. McCANN
Petroleum Engineering and Geology
SHREVEPORT, LOUISIANA
Slattery Building Phone: 2-8023

M. M. MONTGOMERY
CONSULTING PETROLEUM ENGINEER
Valuations, Drilling, Well Completions,
Production, Workovers, Property Management
Hapip Bldg. Williston,
3-4642 North Dakota

OILFIELD SERVICE COMPANY
Electric Logs — Gamma Ray — Caliper
Water Input Profiles
Specializing in Secondary Recovery
PAWHUSKA, OKLAHOMA

OILFIELD RESEARCH
Core Analysis — Evaluation
Development of Water Flood Projects
Operation of Water Flood Projects
EVANSVILLE, INDIANA
1907 Division Street
PHONES: 6-5591 (Night, 6-4882 or 6-0608)

H. T. OLSEN
PETROLEUM CONSULTANT
Engineering and Unitization
914 Fidelity Union Life Building
Dallas, Texas RAndolph 3746

PETROLEUM CONSULTANTS
Engineering and Geology
E. O. Bennett James O. Lewis
D. G. Hawthorn M. D. Hodges
1552 Esperson Building Houston 2, Texas

KELLER & PETERSON
Petroleum Consultants
Reserve Estimates *Reservoir Analysis*
Petroleum and Geological Engineering
902 W. T. WAGGONER BLDG.
FORT WORTH, TEXAS
Phone: FOrtune 4340
W. O. Keller L. F. Peterson

Rates Upon Request

ERNEST K. PARKS
CONSULTING PETROLEUM ENGINEER
Planning, Direction and Examination of Oilfield Operations, Estimates of Oil and Gas Reserves, Oil Property Valuation
151 N. CANYON VIEW, LOS ANGELES 49, CALIF.
Telephone: Arizona 34832

HARRY H. POWER
PETROLEUM AND VALUATION ENGINEER
Box 1542 University Station
Austin, Texas

E. E. REHN
Consulting Petroleum Geologist
Oil Exploration
Wood Building, 624 Locust Street
EVANSVILLE, INDIANA

SOL SMITH
CONSULTING ENGINEER
PETROLEUM AND NATURAL GAS
Reserves Deliverability
Oil and Gas Proration
913 BROWN BUILDING
AUSTIN, TEXAS PHONE: 89498

WM. H. SPICE, JR.
Consulting Geologist
2101-03 Alamo National Building
SAN ANTONIO 5, TEXAS

TRAFFORD & ASSOCIATES
Geological, Petroleum Engineering and Management Consultants

E. Trafford		Phones
R. Pot	Wales Hotel Bldg.	61212
P. Klaui	10th Floor	61224
	Calgary, Alberta	63132

OU Student Chapter Elects New Officers

Officers for the University of Oklahoma Student Chapter of AIME were elected recently. They are D. Otis Gallas, Kermit, Tex., president; W. C. Sutherland, Archer City, Tex., vice-president; C. V. Kloepfer, Winnipeg, Man., treasurer; O. J. E. Wilson, Calgary, Alta., St. Pat's Council representative; R. L. Flowers, Henderson, Tex., and E. G. Ballmer, Fresno, Cal., engineering open house chairmen; Jon R. Withrow, Seminole, Okla., entertainment committee chairman; and E. E. Harris, Houston, Tex., secretary. W. F. Cloud, professor in the school of petroleum engineering, was elected sponsor of the group.

Employment Notices

The JOURNAL will post notices of men and jobs available. Companies and AIME members are invited to use this space, for which there is no charge. Except as noted below, address replies to: Code (appropriate number), JOURNAL OF PETROLEUM TECHNOLOGY, 800 Fidelity Union Bldg., Dallas 1. Show return address on envelope. These replies will be forwarded unopened and no fees are involved.

Replies to personnel notice P-6 and positions coded Y8914-D8656, Y8035, Y7547 and C1091 below should be addressed to: Engineering Societies Personnel Service, 8 West 40th St., New York 18, N. Y. The ESPS on whose behalf these notices are published here, collects a fee from applicants actually placed.

POSITIONS

♦ Recent graduates for large refiner of petroleum and chemical products. (a) Chemists and chemical engineers for operation analysis, process design or economics. b) Mechanical, electrical and chemical for project engineering, field engineering or equipment inspection. Salaries open. Location, South. Y8914-D8656.

♦ Technical sales engineer for petroleum products sales in Bombay, India. Should have 8 to 10 years' experience in industrial sales, preferably chemical or petroleum. Salary open. Twenty-five per cent premium for overseas service plus cost living and housing allowances. Y8035.

♦ Professor, preferably with PhD degree, to take charge of courses in the field of petroleum production engineering, and also do some research work along the line of reservoir engineering. Attractive salary. Location, Southwest. Y7547.

♦ Sales engineering trainee, 25-29, to sell complete lubricating program to industrials covering full line of petroleum products. Will deal with top management for most part. Must have been an honor student and have definite sales aptitude. Knowledge of industrial machinery desirable. Salary, $400-$450 month. Employer will negotiate fee. Location, Chicago. C1091.

♦ Professor to teach petroleum production courses, and direct and conduct fundamental research in the field of reservoir mechanics. PhD desirable. Salary open. College located in south central United States. Code 549.

♦ Petroleum engineer or geologist with two or three years experience in Louisiana Gulf Coast. Duties will entail preparation and maintenance of detailed structure and isopach maps of South Louisiana fields and evaluations necessary in field studies. Work located in New Orleans with reliable and financially strong concern. Reply giving age, experience in detail, and salary desired. Inquiries will be kept strictly confidential. Our employees know of this ad. Code 554.

PERSONNEL

♦ Geologist-petrographer, MS. Experienced petrographer with training and slight experience in spectrographic analyses. Desires employment. P-6.

♦ Petroleum engineer, BS degree, 10 years' experience in production and reservoir engineering. Eight years with major oil company and two years with small independent. Age 33. Above average academic and professional background. Complete resume upon request. Desires position with either major or independent oil company anywhere in USA or Canada. Code 202.

1954 Branch Officers Automatically Elected

The Nominating Committee's slate for Petroleum Branch offices in 1954 has been elected. Pictures and biographies of the nominees were published in the June issue of the Journal of Petroleum Technology, and election was automatic when no additional nominations were made by the membership.

John R. McMillan, director and vice-president in charge of production for Fullerton Oil Co. in Los Angeles, will head activities of the Branch during the coming year in its highest office, that of chairman. D. W. Akins, Jr., and Thomas C. Frick are the new vice-chairmen. Akins is division engineer for the Ohio Oil Co. in Shreveport, La. Frick is regional co-ordinating manager for operations, exploration, and land with The Atlantic Refining Co., located in Corpus Christi, Tex.

Burton Atkinson, consulting petroleum engineer in Midland, Tex., and William D. Owsley, vice-president for engineering advice to management of Halliburton Oil Well Cementing Co., are the new members of the Executive Committee. They succeed Frick and John S. Bell, whose terms expire in 1954. ★ ★ ★

South Plains Local Section Leads in Branch Membership Drive

The South Plains Section is leading all Petroleum Branch, AIME, sections in the current membership drive with a percentage increase of .233. The drive began this year on March 1 to coincide with the Institute-wide membership drive. It will end December 31.

The South Plains Section leads on the basis of returns recorded as of August 31. The winning section will receive a lantern slide projector or an appropriate substitute if the winning section already has one. The award will be made on the basis of percentage increase in membership. The standings of the various sections on Aug. 31 were:

Section	No. Members March 1	Applications Thru Aug. 31	Per Cent Increase
Dallas	272	17	.063
Delta	184	25	.136
East Texas	67	11	.164
Fort Worth	129	5	.039
Gulf Coast	678	32	.047
Kansas	111	4	.036
Lou-Ark	128	4	.031
Mid-Continent	396	13	.033
North Texas	71	13	.183
Oklahoma City	190	5	.026
Permian Basin	296	15	.051
South Plains	30	7	.233
Southwest Texas	302	19	.063
West Central Texas	31	4	.129
Wyoming	70*	4	.057*
Illinois Basin Chpt.	35*	2	.057*
Pacific Pet. Chpt.	638	23	.036*
*Approximate	Total	203	

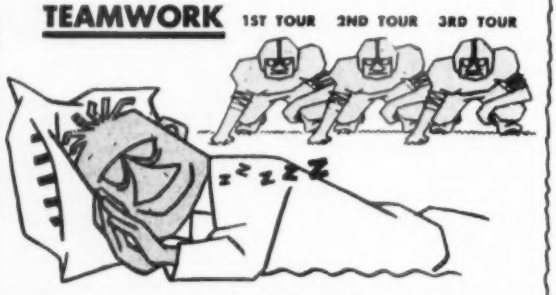
These new applications do not include change-of-status requests. All above applications were received in the office of the Petroleum Branch between March 1 and Aug. 31. Applications received between Jan. 1 and Feb. 28 total 106. In addition, 46 applications were received from foreign countries or miscellaneous sources.

Total new applications received in the Branch office since Jan. 1 are 355.

The Branch Membership Committee is composed of the following members: chairman, M. B. Penn; vice-chairmen, A. M. Shook, Gulf Coast and Southwest Texas area; Gene L. Scheirman, North and East Texas area; A. P. Claudet, Louisiana, Mississippi, and Arkansas area; Raymond E. Howard, West Texas and New Mexico area; Guy F. Williams, Oklahoma and Kansas area; Ray R. Vincent, Illinois Basin area; Wayne E. Glenn, Rocky Mountain area; and Al Frye, California, Washington, and Oregon area. ★ ★ ★

DON'T JUST DREAM ABOUT TEAMWORK

1ST TOUR 2ND TOUR 3RD TOUR



Give your crews the advantages of Geolograph's complete record of drilling operations . . . then watch 'em go for touchdowns! Geolograph just naturally inspires the kind of teamwork that gives you the most hole *at the least cost per foot!*

GEOLOGRAPH

MECHANICAL WELL LOGGING SERVICE

P.O. Box 1291 • Oklahoma City 1, Okla.

Farmington, New Mex. • Liberal, Kan. • Oklahoma City, Okla. • Bakersfield, Cal. Abilene, Houston, Odessa, Lubbock and Wichita Falls, Tex. • Shreveport, and Baton Rouge, La. • Casper, Wyo. • Glendive, Mont. • Sterling, Colo. • Calgary and Edmonton, Alberta, Canada • Regina, Saskatchewan, Canada

Book Reviews

ASTM Manual on Measurement and Sampling of Petroleum and Petroleum Products

American Society for Testing Materials, Philadelphia 3, 1953. 133 p., 9 x 6 in., paper. $1.50.

This compilation, presenting the standard practices most widely used today, provides detailed methods for measuring and computing oil in storage tanks of various types and for getting typical samples. Each section of the book — gauging, temperature measurement, volume calculations, water and sediment, gravity, sampling — includes special instructions and precautions as well as the essential data.

Decimal System for Classisfying Data Pertaining to the Petroleum Industry

By Lester Uren. University of California Press, Berkeley and Los Angeles, 1953. 94 p., 11 x 8¾ in., paper. $2.50.

A thorough, logical classification which is sufficiently extensive to provide a place for relatively specialized items. As in other decimal systems the large classes are general in scope with the additional digits providing the breakdown into the more specific subdivisions. A complete, alphabetical subject index to the classification is included, and the author gives brief instructions on its effective application to a collection or accumulation of material.

Reviews of Petroleum Technology (Volume 13 — 1951)

George Sell, editor. Institute of Petroleum, London, 1953. 360 p., 9¼ x 6¼ in., bound. 50s.

Advancements in the field as written up during the year indicated are discussed critically by British specialists under 22 major headings covering a wide range of topics, including geology, drilling, production, refining, instrumentation, petroleum gases, lubricants, oils from shale and other materials, and various special products. A considerable bibliography is cited in addition to the literature references accompanying each chapter.

Schedule of Local Section Meetings

DALLAS SECTION

Meeting City: Dallas, Tex.

CHAIRMAN	SECRETARY
E. R. Brownscombe	T. E. Morton
Atlantic Ref. Co.	Halliburton
Dallas, Tex.	Dallas, Tex.
PR-6484	RI 3841

Meets third Monday each month

DELTA SECTION

Meeting City: New Orleans, La.

ACTG. CHRM.	SECRETARY
A. L. Vitter	Byron L. Francis
California Co.	The Texas Co.
New Orleans, La.	New Orleans, La.
	CA-8592

Meets second Tuesday each month

EAST TEXAS SECTION

Meeting Place: Gregg County Airport

CHAIRMAN	SECRETARY
H. L. Long	H. D. Miller
Independent Oil Op.	Amerada Pet. Corp.
Kilgore, Tex.	Longview, Tex.
Phone 4416	Phone 1878

Meets second Tuesday each month

FORT WORTH SECTION

Meeting City: Fort Worth, Tex.

CHAIRMAN	SECRETARY
H. J. Gruy	T. M. Curtis
Consultant	Stanolind Oil & Gas
Fort Worth, Tex.	Fort Worth, Tex.
FO-6157	FO-5661

Meets third Tuesday each month

GULF COAST SECTION

Meeting City: Houston, Tex.

CHAIRMAN	SECRETARY
Kenneth B. Ford	Pete Cawthon, Jr.
J. R. Butler & Co.	City National Bank
Houston, Tex.	Houston, Tex.
AT-9455	FA-2131

Meets third Tuesday each month

ILLINOIS BASIN CHAPTER

Meeting City: Salem, Ill.

CHAIRMAN	SECRETARY
Jerry Vaughan	Harry Bridges
Sun Oil Co.	Shell Oil Co.
Evansville, Ind.	Centralia, Ill.
Phone 3-4291	Phone 711

Meets first Thursday each month
(No meetings during July and August)

KANSAS SECTION

Meeting Cities: Wichita and Great Bend, Kans.

CHAIRMAN	SECRETARY
J. R. Puckett	John T. Gary
Magnolia Pet. Co.	Continental Oil Co.
Wichita, Kans.	Wichita, Kans.
4-1301	7-8347

Meets second Wednesday in Wichita, fourth Thursday in Great Bend
(No meetings during June, July and August)

LOU-ARK SECTION

Meeting City, Shreveport, La.

CHAIRMAN	SECRETARY
A. H. Crawford	L. R. Lacy
Crawford Drilling Co.	Phillips Pet. Co.
Shreveport, La.	Shreveport, La.
4-4441	2-3124

Meets tentatively first Monday each month

MID-CONTINENT SECTION

Meeting City: Tulsa, Okla.

CHAIRMAN	SECRETARY
G. C. MacDonald	F. H. Callaway
Gulf Oil Corp.	Stanolind Oil & Gas Co.
Tulsa, Okla.	Tulsa, Okla.

Meets second Monday each month
(Study Group meets fourth Tuesday each month)
(Luncheon meetings each Thursday, Mayo Hotel)

NORTH TEXAS SECTION

Meeting City: Wichita Falls, Tex.

CHAIRMAN	SECRETARY
Rollie P. Dobyns	John H. Bolstad
U. S. Bureau of Mines	Continental Oil Co.
Wichita Falls, Tex.	Wichita Falls, Tex.

Meets second Monday each month

MISSISSIPPI SUB-SECTION

(of Delta Section)

Meeting Cities: Laurel, Jackson and Natchez, Miss.

CHAIRMAN	SECRETARY
John A. Rodgers	Paul Tsimortos
Gulf Refining Co.	Gulf Refining Co.
Lumberton, Miss.	Lumberton, Miss.
Phone 4501	Phone 4653

OKLAHOMA CITY SECTION

Meeting City: Oklahoma City, Okla.

CHAIRMAN	SECRETARY
L. F. Elkins	C. R. Miller
Sohio Petroleum Co.	Schlumberger
Oklahoma City	Oklahoma City
RE-90511	RE-91487

Meets third Thursday each month

PACIFIC PETROLEUM CHAPTER

Meeting City: Los Angeles, Calif.

CHAIRMAN	SECRETARY
F. L. Wadsworth	C. K. Ferguson
General Pet. Corp.	California Research
Los Angeles, Calif.	La Habra, Calif.
MA6-5711	OX7-1721

PERMIAN BASIN SECTION

Meeting Cities: Midland and Odessa

CHAIRMAN	SECRETARY
J. C. Blackwood	Maurice Lewis, Jr.
Amerada Pet. Corp.	British-American Oil
Midland, Tex.	Midland, Tex.
Phone 4-5533	Phone 4-8021

Meets third Monday each month

SAN JOAQUIN VALLEY GROUP

(of Pacific Petroleum Chapter)

Meeting City: Bakersfield, Calif.

CHAIRMAN	SECRETARY
R. P. Mangold	C. A. Davis
D. K. Partnerships	Richfield Oil Corp.
Bakersfield, Calif.	Bakersfield, Calif.
Bakersfield 32561	Maricopa 92631

Meets first Tuesday alternate months
(Feb., April, June, Aug., Oct., Dec.)

SOUTH PLAINS SECTION

Meeting City, Lubbock, Tex.

CHAIRMAN	SECRETARY
J. W. Brown	J. B. Livingston
Stanolind Oil & Gas	Haliburton Oil Well
Brownfield, Tex.	Cem. Co.
Phone 2166	Lubbock, Tex.
	Phone 5-5725

Meets third Thursday each month

SOUTHWEST TEXAS SECTION

Meeting City: Corpus Christi, Tex.

CHAIRMAN	SECRETARY
Ivan Tucker	Chester L. Wheless
Atlantic Ref. Co.	La Gloria Corp.
Corpus Christi, Tex.	Corpus Christi ,Tex
Phone 3-9372	Phone 3-8553

Meets third Wednesday each month
(No meetings July, August and December)

WEST CENTRAL TEXAS SECTION

Meeting City: Abilene, Tex.

CHAIRMAN	SECRETARY
J. L. Coulson	J. E. Russell
Warren Pet. Corp.	Reddin Oper. Comm.
Abilene, Tex.	Abilene, Tex.
Phone 4-8113	Phone 2-4031

Meets third Wednesday each month

WYOMING SECTION

Meeting City: Casper, Wyo.

CHAIRMAN	SECRETARY
R. D. Ferguson	W. R. Kahla
U. S. Geological Surv.	Ohio Oil Co.
Casper, Wyo.	Casper, Wyo.
Phone 3-4561	Phone 3-5721

Meets in alternate months
(No specific dates set)

AIME MEETING CALENDAR

Petroleum Branch Fall Meeting — Oct. 18-21, 1953, Baker and Adolphus Hotels, Dallas, Tex.; Oct. 17-20, 1954, San Antonio, Tex.

Pacific Petroleum Chapter Fall Meeting — Oct. 1-2, 1953, Ambassador Hotel, Los Angeles, Calif.

AIME Fall Meeting — Oct. 29-31, 1953, El Paso, Tex.

AIME Annual Meeting — Feb. 14-18, 1954, Statler Hotel, New York, N. Y.

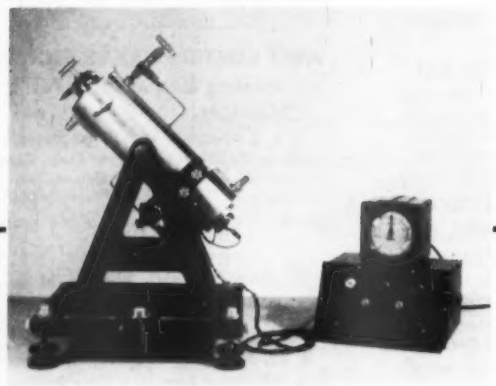
Marcel Schlumberger Dies At Family Home in France

Marcel Schlumberger, co-founder of the Schlumberger Well Surveying Corp., died of a heart ailment last August, while vacationing at the family estate in Normandy, France.

Since 1946, when he resigned the presidency of the firm, he had served as director and had devoted most of his time to research, adding new ideas, inventions, tools and services to the organization's activities.

The contributions of Schlumberger and his late brother, Conrad, to the development and application of electric logging techniques were recognized in 1941, when they were awarded the Anthony F. Lucas Gold Medal. One of the four major awards of the AIME, the medal is given for "distinguished achievement in improving the technique and practice of finding and producing petroleum."

Marcel Schlumberger was born in Alsace June 21, 1884. He was graduated from the Ecole Centrale of Paris in 1907, with a civil engineering degree. He worked as research engineer with various industrial organizations, and served during the first World War in the French tank corps, earning the Legion of Honor. After the war, he joined his brother in developing the new science of electrical prospecting, which was then in its theoretical and embryonic stage. After the death of his brother in 1936, he assumed the presidency of the corporation.



High Pressure Viscosimeter

INSTRUMENTS for the Oil Industry

Ruska Instrument Corporation specializes in the development and manufacture of scientific instruments for the oil and mining industries.

- **Reservoir Engineering**
- **Pressure Measurement**
- **Volumetric Pumps**
- **Core Analysis**

Ask for New, Complete 1953 CATALOG

Ruska Instrument Corporation

4607 MONTROSE BLVD. HOUSTON 6, TEXAS

Advertisers' Index

American Iron & Machine Works . . . . . *
Lowe Runkle Co., Oklahoma City, Okla.

Baash-Ross Tool Co. . . . . *
Dozier-Eastman Co., Los Angeles, Cal.

Baker Oil Tools, Inc. . . . . *
Theo. M. Martin Co., Los Angeles, Cal.

Baroid Sales Division . . . . . *
Brennan Advertising, Houston, Tex.

B & W, Inc. . . . . Sec. 1 — 5
Brennan Advertising ,Houston, Tex.

Byron Jackson Co. . . . . Fourth Cover
Ruthrauff & Ryan, Los Angeles, Cal.

Clark Bros. Co., Inc. . . . . *
Harold Warner Co., Buffalo, N. Y.

Cooper-Bessemer Corp. . . . . Sec. 1 — 2
Griswold-Eshleman Co., Cleveland, Ohio

Core Laboratories, Inc. . . . . *
Duvall Williams, Dallas, Tex.

Dowell Incorporated . . . . . Sec. 1 — 8, 9
MacManus, John & Adams, Inc., Detroit, Mich.

Dresser Industries, Inc. . . . . Third Cover
Laughlin, Wilson, Baxter & Persons, Dallas, Tex.

Eastman Oil Well Survey Co. . . . . *
Ted Workman Advertising, Dallas, Tex.

Geolograph Co. . . . . Sec. 2 — 6
Lowe Runkle Co., Oklahoma City, Okla.

Geological Well Service Co. . . . . *
Matlock-Wilson Advertising, Dallas, Tex.

Halliburton Oil Well Cementing Co. . . . Sec. 1 — 1, 14
Hill & Christopher, Los Angeles, Cal.

Harbison-Fisher Mfg. Co. . . . . *
Dan Goodrich, Dallas, Tex.

Hughes Tool Co. . . . . *
Foote, Cone & Belding, Houston, Tex.

Hycalog Co. . . . . *
Glenn Mason Advertising, Shreveport, La.

Johnston Testers, Inc. . . . . Sec. 1 — 6
Wallace Davis & Co., Houston, Tex.

Journal of Petroleum Technology . . . . . Sec.1 — 4
Dan Goodrich, Dallas

Kobe, Inc. . . . . *
The McCarty Co., Los Angeles, Cal.

Kimray, Inc. . . . . *
Brandenburg Advertising, Tulsa, Okla.

Lane-Wells Co. . . . . Sec. 1 — 24
Darwin H. Clark Co., Los Angeles, Cal.

Lufkin Foundry & Machine Co. . . . . Sec. 1 — 10
A. E. Cudlipp, Lufkin, Tex.

Magnet Cove Barium Corp. . . . . Third Cover
Rives, Dyke & Co., Houston, Tex.

McCullough Tool Co. . . . . Sec. 1 — 23
R. P. Casterline, Los Angeles, Cal.

Mission Manufacturing Co. . . . . *
Rives, Dyke & Co., Houston, Tex.

Oil Base, Inc. . . . . Sec. 1 — 13
Dozier-Eastman & Co., Los Angeles, Cal.

Oil Center Tool Co. . . . . *
Rives, Dyke & Co., Houston, Tex.

Otis Pressure Control, Inc. . . . . Sec. 2 — 3
Dan Goodrich, Dallas, Tex.

Pelton Water Wheel Co. . . . . *
Edward A. Stratman, Huntington Park, Cal.

Professional Services . . . . . Sec. 2 — 4, 5

Reed Roller Bit Co. . . . . *
Brennan Advertising, Houston, Tex.

Ruska Instrument Corp. . . . . Sec. 2 — 8
Brennan Advertising, Houston, Tex.

Schlumberger Well Surveying Co. . . . Second Cover
Rives, Dyke & Co., Houston, Tex.

United Geophysical Co., Inc. . . . . *
Dozier-Eastman Co., Los Angeles, Cal.

Welex Jet Services, Inc. . . . . *
Evans & Assoc., Fort Worth, Tex.

Western Geophysical Co. . . . . *
L. J. Swain Advertising, Whittier, Cal.

*In Previous Issues

More Magcobar Coming Up!

From this new Magcobar plant at Brownsville, Texas, now comes additional production of Magcobar Heavy Mud Weight to meet the increased needs of the oil industry. You can be *sure* of the quality . . . at fair and reasonable prices . . . when it's in the Magcobar bag. Magcobar products are available day or night through nearly 400 strategically located dealers from border-to-border, coast-to-coast.

Another Magcobar barite processing plant . . . Brownsville, Texas

Our Name is Mud!

MAGNET COVE BARIUM CORPORATION
ONE OF THE DRESSER INDUSTRIES
HOUSTON, TEXAS

MAGCOBAR PRODUCTS

- MAGCOBAR
- MAGCOGEL
- HIGH YIELD
- XACT CLAY
- SALT GEL
- MY-LO-JEL
- MY-LO-JEL PRESERVATIVE
- DRISCOSE
- FORM-A-PLUG
- CELL-O-SEAL
- FIBER SEAL
- MAGCO FIBER
- LEATHER-FLOC
- MAGCO MICA
- JEL-OIL MUD
- JEL-OIL "E"
- "E" CONCENTRATE
- NOHEEV
- TANNATHIN
- RED OX LIQUID
- ALKATAN
- QUEBRACHO
- KEMBREAK
- MAGCOPHOS
- CHEMICALS

Magcobar
Complete
DRILLING MUD SERVICE
DEALER

high
lift
at
low
operating
cost

BJ

Hydralift

BJ
Hydralift

Byron Jackson Co.